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# ***JPRS Report***

# **Science & Technology**

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***USSR: Space***

13 JULY 1987

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## SCIENCE &amp; TECHNOLOGY

## USSR: SPACE

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS CONTINUE PHOTOGRAPHY, ATMOSPHERE STUDIES

Moscow KRASNAYA ZVEZDA in Russian 25 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center, 24 March. Yuriy Romanenko and Aleksandr Laveykin have been working on board the manned complex "Mir" for 45 days.

Today a considerable portion of the crew's working time is devoted to geo-physical studies. Plans call for observing and photographing the territory of the Soviet Union in the middle and southern latitudes, and for experiments to be performed for further study of the upper layers of the Earth's atmosphere.

Work with the automatic transport ship "Progress-28" is being completed. The cosmonauts have moved the items that it delivered into the rooms of the base block of the complex, and they are filling the empty compartment of the transport ship with depleted equipment. The tanks of the station's engine unit have been refueled.

The work in near-Earth orbit is proceeding in accordance with the designated program.

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## MANNED MISSION HIGHLIGHTS

### SEMICONDUCTOR CRYSTAL PRODUCTION ABOARD 'MIR'

Moscow KOMSOMOLSKAYA PRAVDA in Russian 26 Mar 87 p 2

[Article by S. Leskov, correspondent at the Flight Control Center]

[Excerpt] The mission of Soviet cosmonauts Yuriy Romanenko and Aleksandr Laveykin continues on board the orbiting complex "Mir"--"Soyuz TM-2"--"Progress-28." The crew has begun complex technological experiments and Earth-resources studies.

The cosmonauts have tripped the shutters of the cameras "Sever" and "KATE-140" literally hundreds of times. Space photographs of the Earth's surface have proved indispensable for substantiating academician V.B. Sochava's 'theory of geosystems'. Thanks to the work of the cosmonauts and their predecessors on board Soviet orbiting stations, the USSR Academy of Sciences has been able to organize a huge project: a new edition of the geographic WORLD ATLAS, with hundreds of substantial corrections. Lately, Romanenko and Laveykin have been transmitting to Earth invaluable information on the movement of mudslides, at a time when bad weather threatens disasters.

The cargo spaceship "Progress-28" delivered a unique apparatus, "Korund-1M," to the orbiting station. This apparatus which weighs 130 kilograms, is intended for perfecting basic processes for producing semiconductor materials on an industrial scale in space.

"Cadmium sulfide crystals which were grown on board 'Salyut-7' were used in laser screens for projection television," related Candidate of Technical Sciences Ye. Markov, the experiment's director. "You may be sure that we would never have obtained the quality we did if it hadn't been for space.

"Space flight is expensive, of course. But delivering materials to distant orbits pays for itself many times over. Here are some figures. The number of usable crystals per wafer grown in space is 10 times greater than the number obtained on Earth. Profit per wafer is 1,900 rubles for 'terrestrial' wafers, and 9,400 rubles for 'space' ones. Isn't that convincing? Work on semiconductor-materials science must therefore be expanded to the maximum. Romanenko and Laveykin are to perform exactly 48 experiments with the 'Korund',

involving specimens with the most diverse properties and possible applications. Among them are such rare and extremely valuable semiconductors as cadmium sulfide, zinc oxide and gallium arsenide."

"But when will we finally proceed from experiments to industrial production?" I asked Ye. Markov.

"By 1995, we hope to be able to obtain semiconductor materials for various purposes in amounts of 30-35 kilograms each. These materials will be used in superhigh-speed and superlarge integrated circuits, in infrared and laser technology, in photocells for orbiting stations' solar panels, and even for needs of medicine, which is waiting for sensitive infrared imagers, for example. Let me emphasize that this is a high-priority direction for the advancement of Soviet science, and we are not running second to anyone here."

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## MANNED MISSION HIGHLIGHTS

### TASS REPORTS UNDOCKING OF 'PROGRESS-28'

Moscow IZVESTIYA in Russian 27 Mar 87 p 1

[TASS Report]

[Text] Flight Control Center. After completion of the program of joint flight, the automatic transport spaceship "Progress-28" was separated from the orbiting complex "Mir" at 0807 hours Moscow time.

All operations planned during this period--unloading the spaceship, refilling tanks of the station with fuel and an oxidizer and transferring drinking water--were performed in their entirety. Two corrections of the complex's orbit were executed with the aid of the cargo ship's engine.

The seventh week of Yuriy Romanenko's and Aleksandr Laveykin's space mission is ending. Today the crew is performing another series of geophysical studies and a number of technical experiments.

The work in near-Earth orbit is continuing.

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## MANNED MISSION HIGHLIGHTS

### DESTRUCTIVE REENTRY OF 'PROGRESS-28'

Moscow IZVESTIYA in Russian 29 Mar 87 p 2

[TASS Report]

[Text] Flight Control Center, 28 March. The flight of the unmanned transport ship "Progress-28," which was launched into near-Earth orbit on 3 March 1987, has ended.

Today on commands from the Control Center, the cargo ship was oriented in space, and at 0559 hours, Moscow time, its engine was fired. As a result of braking, the "Progress-28" ship went into a descending trajectory, entered the dense layers of the atmosphere, and ceased to exist.

Yuriy Romanenko and Aleksandr Laveykin are continuing their work on board the manned complex "Mir." In line with the program of space materials studies, yesterday they performed a number of experiments to investigate thermocapillary effects in liquid immiscible systems, using the "Pion-M" unit.

The crew's plans for today call for conducting another melt in the "Korund" unit, for performing an experiment to study the dynamics of the structure of formation of aero- and hydrosols in zero gravity, and for damp-mopping of the station's rooms. Time also is set aside for rest and physical exercise.

Both cosmonauts are feeling well and are in good spirits.

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## MANNED MISSION HIGHLIGHTS

### LAUNCH OF 'KVANT' ASTROPHYSICS MODULE

Frunze SOVETSKAYA KIRGIZIYA in Russian 1 Apr 87 p 1

[TASS Report]

[Text] TASS announcement--In line with the space research program, a specialized astrophysics module, "Kvant," was carried into near-Earth orbit by a "Proton" launch rocket on 31 March 1987.

The astrophysics module is intended for conducting a wide range of studies in the field of extra-atmospheric astronomy and for accomplishing a number of other scientific and economic tasks. The scientific equipment carried by the module includes an international orbiting observatory called "Rentgen" (X-ray), which was developed by scientists of the Soviet Union, Great Britain, the Netherlands, the Federal Republic of Germany, and the European Space Agency, and also an ultraviolet telescope, "Glazar," which was developed in the USSR with the participation of specialists from Switzerland.

According to telemetry data, all systems of the "Kvant" module are functioning normally.

Maneuvering of the astrophysics module "Kvant" in orbit is accomplished with the aid of a service unit which is equipped with an engine. Docking of the module with the manned complex "Mir" is planned for 5 April.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS CONTINUE MATERIALS EXPERIMENTS

Leningrad LENINGRADSKAYA PRAVDA in Russian 3 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 2 April--The Eighth week of the space mission of Yuriy Romanenko and Aleksandr Laveykin is drawing to a close.

The crew's plans for today call for routine preventive maintenance work on the station and for technological experiments using the "Korund" apparatus.

In line with the space materials science program, another series of experiments in the "Pion-M" unit was conducted yesterday. The experiments were intended to investigate convection currents in unevenly heated liquids under the effect of surface-tension forces.

The flight of the astrophysics module "Kvant" is continuing. Following orbit corrections which were executed with the engine of the service unit, the module's orbit parameters are: maximum distance from Earth's surface--364 kilometers; minimum distance from Earth's surface--297 kilometers; period of revolution--90.9 minutes; inclination--51.6 degrees.

According to results of telemetry, the flights of the manned complex "Mir" and of the specialized orbiting module "Kvant" are proceeding normally.

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## MANNED MISSION HIGHLIGHTS

### BLAGOV COMMENTS ON FEATURES OF 'KVANT' MODULE

Riga SOVETSKAYA LATVIYA in Russian 1 Apr 87 p 3

[Article by V. Ovcharov, TASS correspondent at the Flight Control Center]

[Excerpt] A powerful "Proton" launch rocket has lifted a new kind of spacecraft--the first specialized module "Kvant"--into near-Earth orbit. It is intended for 'building up' the scientific station 'Mir' and for performing astrophysical and other scientific research. The starting weight of the module together with its service unit is 20.6 tons.

"We began talking about such modules, which open up a new chapter in manned space flight, after 'Mir' was launched," said deputy flight director V. Blagov, USSR State Prize laureate, commenting on this news. "The 'Mir' station is different from all of its predecessors in that it can be 'added on to' in orbit, depending on the purposes of a mission. This is made possible by one of its two main sections, which is sphere-shaped and has five docking mechanisms to which different specialized modules can be attached in the course of a flight. There is a sixth docking mechanism located at the rear end of the base block, and it is to this mechanism that the first space module will be docked. How can this module be described?

"I'll begin by noting that it went into orbit together with its own 'booster,' a service unit which will be separated after the 'Kvant' has docked with the station. The weight of the module as part of the complex then will be 11 tons; the length will be 5.8 meters, and the diameter at the widest part will be 4.15 meters. The 'Kvant' consists of a laboratory compartment with an entry chamber, and a scientific-instrument compartment. The first compartment and its chamber are airtight and have a volume of 40 cubic meters. The instrument compartment is not airtight. One-and-a-half tons of scientific instruments and more than 2.5 tons of equipment are installed on the module.

"The basic equipment is located in the laboratory compartment. The equipment is arranged in an instrumentation zone, which is separated from the central living zone by decorative panels. Inside the laboratory compartment are instruments and units of systems for controlling the onboard [equipment] complex, for

controlling movement, for rendezvousing and docking, for measurements, and for maintaining the gas composition and regulating the temperature. Also installed here is equipment of the integrated radio system, and of the telephone and telegraph system and also television. This compartment has two windows. The first, which is 43 centimeters in diameter, is intended for setting up an optical sight. The second window, which is 22.8 centimeters across, has a visual astro-orientation device mounted on it.

"Two more windows which are 8 centimeters in diameter are located in the entry chamber. They are intended for visual observations. Also located here is an airlock chamber for servicing the ultraviolet telescope 'Glazar,' which was developed by scientists of the Byurakan Observatory with the participation of specialists from Switzerland, and also the control console for it.

"Finally, the scientific-instrument compartment kind of encircles the entry chamber. It is intended for placing scientific apparatus and also instruments and units which operate in open space on the module. These comprise first of all the international orbital observatory 'Rentgen,' which weighs 800 kilograms. This observatory includes a telescope-spectrometer for hard x-rays called 'Pulsar X-1', a high-energy scintillation telescope-spectrometer called 'Fosvich', a telescope with a so-called shadow mask, and also a gas scintillation proportional spectrometer called 'Siren-2.' Also located in this compartment are the 'Glazar' telescope and an automated electrophoresis unit called 'Svetlana' for biotechnology experiments."

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## MANNED MISSION HIGHLIGHTS

### PROJECT DIRECTOR COMMENTS ON 'KVANT' SCIENTIFIC INSTRUMENTS

Moscow KOMSOMOLSKAYA PRAVDA in Russian 1 Apr 87 p 1

[Article by S. Leskov, correspondent at the Flight Control Center]

[Excerpt] The "Kvant" module, which is to be docked with the "Mir" orbiting station, is literally crammed with instruments which make it possible to peer beyond the clouds and to learn secrets of the stars which are hidden from the keenest and most ingenious observers. R.A. Syunyayev, corresponding member of the USSR Academy of Sciences and director of the orbiting observatory, related the following about the scientific research program:

"We are witnessing the birth of a large orbiting observatory. The weight of the scientific instruments on the module is about one-and-a-half tons. The 'Kvant' is a very powerful astrophysical complex, whose development involved scientists of the USSR, the Netherlands, the Federal Republic of Germany (FRG), Great Britain and the European Space Agency. A telescope with a shadow mask was developed by the State University of Utrecht in the Netherlands and the University of Birmingham in England. This instrument makes it possible to construct an image of the sky in the X-ray range. We hope to be able to view the most mysterious objects--black holes, neutron stars, and clusters of active galaxies.

"The gas scintillation proportional spectrometer 'Siren-2' was developed at the European Space Agency's technical center. It has a high sensitivity in the X-ray range. Clusters of galaxies contain hot rarefied intergalactic gas at temperatures which plasma units on Earth still have not succeeded in reaching.

"The 'Fosvich' high-energy scintillation telescope-spectrometer was developed by the Institute of Extra-Atmospheric Physics of the Max-Planck Society (FRG). Soviet scientists had predicted the phenomenon of electron emission in a strong magnetic field. The specialists from the FRG developed an instrument which records electron emission in the ultrahigh-strength fields of neutron stars.

"And, finally, the fourth instrument, which operates in the hard X-ray range, is the 'Pulsar X-1' telescope-spectrometer, which was developed at the USSR Academy of Sciences' Institute of Space Research."

Rashid Aliyevich Syunyayev could talk forever about the "Pulsar." It seems that astronomers place especially high hopes in this telescope. Its main task is to study the spectra of galactic nuclei and of the mighty quasars, whose nature is not fully understood. Another very interesting problem is the study of a mysterious object at the center of our Galaxy, where the elusive antimatter might exist.

Specialized modules are a landmark of fundamental importance in the advancement of space exploration. And the first such module in orbit is Soviet. The many millions of British pounds sterling, West German marks and Dutch guilders which were invested in equipping it bear witness to the confidence placed in Soviet cosmonautics.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUT COMMENTS ON CURRENT ACTIVITIES

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 4 Apr 87 p 1

[Article by G. Lomanov, correspondent at the Flight Control Center]

[Abstract] The article records an interview with cosmonauts Yuriy Romanenko and Aleksandr Laveykin on the orbiting station "Mir." Flight controllers permitted a few questions during a period of communication with the crew. The cosmonauts commented on the progress of their mission and on equipment of the astrophysical module "Kvant" which was on its way to the orbiting station, and they compared the module's instruments with ones used previously on space stations.

Asked about their recent activities, the cosmonauts said they had taken many photographs of Earth's surface with the cameras "KATE-140," which they described as a high-precision topographic camera, and "Sever." The latter is aimed at an angle rather than straight down, which makes it possible to obtain photographs showing geological structures in relief. The cosmonauts reported also that the first industrial specimens of semiconductor materials had been obtained in the "Korund 1-M" unit.

Regarding the instruments of the "Kvant" module, the cosmonauts commented on an ultraviolet telescope, "Glazar," which was developed at the Byurakan Astrophysical Observatory. "Glazar" is said to be a successor to telescopes of the "Orion" series, the first of which was used on a "Salyut" station in 1971, and the second of which was used two years later by cosmonauts P. Klimuk and V. Lebedev on "Soyuz-13." Hundreds of spectrograms could be obtained in a single exposure with "Orion-2," whereas "Orion-1" provided only spectra of individual stars.

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## MANNED MISSION HIGHLIGHTS

### 'KVANT' CONTROL SYSTEM MALFUNCTIONS, DOCKING POSTPONED

Moscow IZVESTIYA in Russian 6 Apr 87 p 2

[TASS Report]

[Text] Flight Control Center, 5 April. Maneuvers for initial rendezvousing of the specialized module "Kvant" with the manned complex "Mir" from afar were executed today. The flight of both orbiting spacecraft proceeded according to program up to a distance of 200 meters.

In the final stage, due to irregular functioning of the control system of the astrophysical module "Kvant," the rendezvousing of the spacecraft was halted.

At the present time telemetry information is being analyzed, and a decision will be made regarding further work with the module according to the results of this analysis.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS ROMANENKO AND LAVEYKIN COMPLETE SECOND MONTH IN ORBIT

Moscow PRAVDA in Russian 8 Apr 87 p 2

[TASS Report]

[Text] Flight Control Center, 7 April. The second month of the flight of Yuriy Romanenko and Aleksandr Laveykin on board the orbiting complex "Mir" is coming to an end. In this time the cosmonauts have performed planned work on equipping the base block with additional equipment that was delivered by two cargo ships, and they have also done a considerable amount of research and experiments.

Today the crew is checking the functioning of individual instruments and scientific apparatus, and they are preparing for upcoming work.

According to results of medical monitoring that was performed yesterday, the health of Yuriy Romanenko and Aleksandr Laveykin is good.

The space mission is continuing.

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## MANNED MISSION HIGHLIGHTS

### DUNAYEV COMMENTS ON 'KVANT' DOCKING PROBLEM

Moscow KOMSOMOLSKAYA PRAVDA in Russian 8 Apr 87 p 4

[Article by S. Leskov, correspondent at the Flight Control Center]

[Excerpt] As has been reported, the docking of the module "Kvant" with the orbiting station "Mir," which was scheduled for 5 April did not take place. Readers have been telephoning the newspaper, asking about the reason for the failure. Will new attempts be made to link up the two giant spacecraft?

A.I. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research, responded to these questions:

"An irregular situation occurred in the space orbit on Sunday night. During the rendezvousing of the spacecraft, which was proceeding strictly according to the calculated flight path, the system 'Igla' installed on the 'Kvant' module suddenly 'lost' the orbiting station when the module was approximately 200 meters from it. Specialists immediately began to analyze the situation. It must be said that the docking problem does not mean that the program has become a failure, as a number of Western wire services have been representing the episode. We understand clearly enough what happened in orbit. Requirements for the mutual positioning of the spacecraft in the in-close phase of their flight paths were set much too rigid. The technical name for such a situation is 'logic of tolerances.' What we had fed into the computer, we obtained as a result. There is no panic at the Control Center. The 'Kvant' has enough fuel in its tanks for repeated docking attempts, if necessary. We do not intend to keep the next scheduled date a secret. Specialists are now carefully calculating the optimum procedure for docking the module with the station."

Dunayev, V.I. Lobachev, director of the Flight Control Center, and pilot-cosmonaut V.V. Ryumin, the flight director, spoke to Soviet and foreign journalists at a press conference which was held at the Flight Control Center. The journalists were afforded a rare opportunity for addressing their questions to the cosmonauts in orbit. We saw Yuriy Romanenko and Aleksandr Laveykin on a huge screen in the control room. The crew appeared undisturbed by the many questions they were asked.

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MANNED MISSION HIGHLIGHTS

TASS REPORTS 'KVANT' LINKUP WITH 'MIR' STATION, HARD DOCKING NOT ACHIEVED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 10 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 9 April. The astrophysical module "Kvant" docked with the orbiting complex "Mir" today at 0436 hours Moscow time.

The mutual search, approach, rendezvousing and docking were carried out with the aid of onboard automatic equipment of the spacecraft. These processes were monitored by the Flight Control Center interacting with the ground command-and-measurement complex, and also by cosmonauts Yuriy Romanenko and Aleksandr Laveykin. The "Kvant" module docked with the station on the side where its equipment compartment is located.

The module's onboard systems functioned normally at all stages of the rendezvousing and docking. The process of securing the module tightly to the station began after the docking mechanisms of the spacecraft had been mechanically connected. Analysis of telemetry information received from the spacecraft indicated that tight securing of the "Kvant" module to the orbiting station "Mir" had not been fully accomplished.

Data are now being studied, and a decision in regard to further work with the module will be made on the basis of results of the study.

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## MANNED MISSION HIGHLIGHTS

### ACTIVITIES AT FLIGHT CONTROL CENTER DURING 'KVANT'-'MIR' LINKUP

Leningrad LENINGRADSKAYA PRAVDA in Russian 10 Apr 87 p 3

[Article by V. Ovcharov, special correspondent at the Flight Control Center]

[Excerpt] The situation which developed in orbit on the morning of 9 April had never before occurred in the practice of Soviet manned space flight. After the astrophysical module "Kvant" had gripped the docking mechanism of the "Mir" station, the so-called process of tight securing of the module to the station began, but it did not proceed to completion. The coupling of the module and the orbiting complex was a few centimeters shy of the correct fit.

It was the dead of night in Moscow when cosmonauts Romanenko and Laveykin awoke, changed into space suits, and went inside the spaceship "Soyuz TM-2." These precautionary measures are always taken before a docking. They are all the more justified when two 20-ton spacecraft are meeting in orbit.

"After the [first] rendezvous was cut short on 5 April, the module and the orbiting complex consisting of the station and the manned spaceship drifted 400 kilometers apart," reported Doctor of Technical Sciences V. Pochukayev, director of the ballistic service. "We brought the two objects closer together by a few maneuvers of 'Kvant.' And when the distance between them had decreased to 22 kilometers, the automatic docking system 'Iгла' was switched on. Look at the chart: the spacecraft are now only a few kilometers apart."

At 0415 hours the following message was received through telemetry channels: "'Lock-on' signal formed." This meant that the "Iгла" system was guiding the spacecraft surely to a linkup.

The most critical stage now began. The velocity of the spacecraft with respect to one another was reduced with jeweler's precision: distance separating them--1 kilometer; speed--2.5 meters per second; distance--260 meters, speed--1.6; distance--26 meters, and speed--0.32. Events were developing on the dark side of the Earth, and we were not able to see the usual television picture from orbit, unfortunately. The clock was at 0436 hours when we heard:

"Contact made; mechanical gripping recorded!," reported the operator. "Are you breathing easier?" flight director V. Ryumin asked the crew.

"Naturally," replied Romanenko.

The words "Process of tight-securing of spacecraft in progress" appeared on the Flight Control Center's screen. And then the unexpected happened. After going in for 365 millimeters, a rod of the "Kvant" module's docking mechanism suddenly stopped in its place. The coupled spacecraft left the zone of radio visibility, and specialists began a lively discussion of the situation. On the next orbit, V. Ryumin asked the crew:

"Switch on the outside television camera, and we'll see if we can find out something. Yuriy, you examine the docking mechanism through the windows of the entry chamber, please."

And on subsequent orbits, the specialists continued to analyze the situation with the crew's assistance. For all appearances, however, the orbiting spacecraft had again confronted them with a difficult problem. And it would have to be solved.

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MANNED MISSION HIGHLIGHTS

COSMONAUTS PREPARE FOR EVA TO INSPECT 'KVANT' DOCKING UNIT

Moscow IZVESTIYA in Russian 12 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 11 April. Today, cosmonauts Yuriy Romanenko and Aleksandr Laveykin are busy preparing for an egress into open space. The main purpose of the egress is to examine the docking mechanism of the "Kvant" module.

Plans call for the egress to be made during the night of 11-12 April.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS REMOVE FOREIGN OBJECT, ACHIEVE HARD DOCKING

Moscow IZVESTIYA in Russian 13 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 12 April. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin have made an egress into open space and performed operations which permitted the module "Kvant" to dock completely with the station.

On 11 April at 2341 hours Moscow time, Yuriy Romanenko and Aleksandr Laveykin went outside the station and moved along it to the place where the module was docked. The spacecraft were moved apart from each other as far as possible by pulling out the rod of the module's docking mechanism. While examining the docking mechanisms of the module and the station, the cosmonauts discovered that a foreign object had become lodged between the mechanisms and was preventing them from coming together completely.

After the crew commander and the flight engineer had performed the necessary operations, the tight-securing of the spacecraft was accomplished. This process, which was carried out on commands from Earth and was visually monitored by the crew, proceeded as designed and ended with the module and the station being joined together completely.

The time that Yuriy Romanenko and Aleksandr Laveykin spent in open space was 3 hours and 40 minutes.

The condition of both cosmonauts' health is good, and they are feeling well.

The manned space complex "Mir"--"Kvant"--Soyuz TM-2" is functioning in near-Earth orbit. The total weight of this complex is 51 tons, and it is 35 meters long.

An extensive program of experiments in the field of extra-atmospheric astronomy is to be carried out with the aid of the unique orbiting observatory apparatus "Rentgen" and the ultraviolet telescope "Glazar" which are installed on the module. Sources of X-radiation will be studied in a wide range of wavelengths, and stars of various spectral classes and galaxies will be studied in the ultraviolet part of the spectrum.

In addition to scientific apparatus for astrophysical studies, the module carries an electrophoresis unit, "Svetlana," which is intended for conducting experiments aimed at obtaining test lots of superpure biologically-active substances in zero gravity.

Operation of this specialized module--the first in a series of modules which will become part of a multipurpose, permanent manned complex--will substantially expand opportunities for research in the interests of science and the economy, increase the effectiveness of this research and open up new horizons for international cooperation in the field of peaceful exploration of space.

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## MANNED MISSION HIGHLIGHTS

### PROPULSION UNIT SEPARATED FROM 'KVANT' MODULE

Moscow IZVESTIYA in Russian 14 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 13 April. In line with the flight program of the manned complex "Mir," the service unit which was a component of the astrophysical module "Kvant" was separated from it today at 0018 hours Moscow time. This unit, which is equipped with an engine, was used to execute maneuvers in orbit for rendezvousing and docking the module with the station.

The "Kvant" module has two docking assemblies. The second is located on the side from which the service unit was separated and is intended for receiving transport spaceships.

Yuriy Romanenko and Aleksandr Laveykin are continuing their work on board the scientific research complex. Today they opened the hatch of the "Kvant" module and examined the space laboratory that had arrived. The crew is to reactivate systems and scientific apparatus of this laboratory during the days immediately ahead.

According to telemetry data and reports from orbit, the flight of the manned complex "Mir" is proceeding normally.

Both cosmonauts are healthy and feeling well.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS BEGIN ACTIVATION OF 'KVANT' MODULE

Moscow IZVESTIYA in Russian 17 Apr 87 p 3

[TASS Report]

[Text] Flight Control Center, 15 April. Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are continuing planned operations for putting the astrophysical module "Kvant" into the manned-flight mode.

In addition to scientific apparatus, the module carries a large number of instruments and units which the crew is to incorporate in a unified network of onboard systems of the manned complex during the days immediately ahead.

In particular, the cosmonauts installed a new electronic unit delivered by the "Kvant" module and checked its functioning as a component of an onboard computer today.

Within the framework of the geophysical research program, the crew has performed a series of visual observations and picture-taking of individual areas of land surface and the waters of the world's oceans, using hand-held cameras.

According to reports from orbit, the work on board the manned complex "Mir" is proceeding in accordance with the designated flight schedule.

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MANNED MISSION HIGHLIGHTS

COSMONAUTS ACTIVATING 'KVANT' MODULE, CONDUCT MEDICAL EXAMS

Moscow IZVESTIYA in Russian 18 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 17 April. The 10th week of Yuriy Romanenko's and Aleksandr Laveykin's space mission has ended.

Yesterday the cosmonauts carried out one more stage of work on putting the astrophysical module "Kvant" into the manned-flight mode. In particular, they reactivated components of the gas-mixture supply system and connected sensors installed on the module to the system for orienting the base block's solar batteries.

The latest medical examination of the crew is being performed today. In the morning, the cosmonauts conducted measurements of body mass and evaluated the condition of muscles that are not exerted much in zero gravity. During the second half of the day, the commander and flight engineer will examine their cardiovascular systems in conditions of rest and measured amounts of physical exertion using the stationary bicycle.

According to results of medical monitoring, the condition of Yuriy Romanenko's and Aleksandr Laveykin's health is good and they are feeling well.

The flight of the manned orbiting complex "Mir" is continuing.

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MANNED MISSION HIGHLIGHTS

TASS REPORTS LAUNCH OF 'PROGRESS-29'

Moscow IZVESTIYA in Russian 22 Apr 87 p 1

[TASS Report]

[Text] In line with the program for the further operation of the orbiting scientific station "Mir," an unmanned cargo ship, "Progress-29," was launched from the Soviet Union on 21 April 1987 at 1914 hours Moscow time.

The purpose of the launching of the ship is to deliver to the station materials which become depleted, and also various items of cargo.

The "Progress-29" ship was placed into an orbit with the parameters: maximum distance from the surface of Earth—257 kilometers; minimum distance from the surface of Earth—194 kilometers; period of revolution--88.7 minutes; inclination--51.6 degrees.

According to telemetry data, the onboard systems of the unmanned cargo ship are functioning normally.

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## MANNED MISSION HIGHLIGHTS

### 'PROGRESS-29' DOCKS WITH 'MIR' COMPLEX

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 25 Apr 87 p 1

[Text] The cargo spaceship "Progress-29" docked with the manned complex "Mir" on 23 April 1987, at 2105 hours Moscow time.

For the first time in near-Earth space, a scientific research complex consisting of four components which make up a unified system--a base block, an astrophysical module, a manned ship, and an unmanned ship--has been created by the method of sequential assembly.

The mutual search, approach, rendezvousing and docking were executed with the aid of onboard automation, and were monitored by the Flight Control Center and also by cosmonauts Yuriy Romanenko and Aleksandr Laveykin.

The "Progress-29" ship docked with the complex at the end where the "Kvant" module is located. Fuel for the engine unit, foodstuffs, water, equipment, instruments, and mail were delivered to the orbiting complex.

According to telemetry data and the crew's reports, the onboard systems of the manned complex "Mir" are functioning normally. Yuriy Romanenko and Aleksandr Laveykin are in good health and are feeling well.

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## MANNED MISSION HIGHLIGHTS

### INVENTORY OF CARGO DELIVERED BY 'PROGRESS-29'

Moscow TRUD in Russian 25 Apr 87 p 1

[Article by V. Golovachev, correspondent at the Flight Control Center]

[Abstract] The article reports briefly on the 23 April docking of the unmanned cargo spaceship "Progress-29" with the orbiting complex consisting of the space station "Mir," the astrophysical module "Kvant," and the spaceship "Soyuz TM." Information on the cargo delivered by "Progress-29" is related. The payload was in excess of 2,200 kilograms. Crated and packaged cargo accounted for 1,200 kilograms. There was equipment for scientific research and equipment for onboard systems, including equipment for the system that maintains the gaseous composition of the atmosphere inside the station. There were 140 kilograms of photographic materials, one-fourth ton of foodstuffs, and the rest consisted of medical equipment, items of personal hygiene, and mail. In addition, the "Progress-29" carried three-fourths ton of fuel and 170 kilograms of water, plus fuel of its own which will be used to correct the orbit of the orbiting complex.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS PREPARE FOR EVA TO INSTALL SOLAR PANEL

Moscow IZVESTIYA in Russian 28 Apr 87 p 1

[TASS Report]

[Text] Flight Control Center, 27 April. The long mission of Yuriy Romanenko and Aleksandr Laveykin in Earth orbit is continuing.

In the days just past the cosmonauts have been busy mainly with the unloading of the unmanned ship "Progress-29." They are placing the equipment that it delivered in rooms of the base block and in the astrophysical module.

The mission program of the orbiting station "Mir" calls for increasing the capacity of its power-supply by means of installing another solar panel. This panel, which consists of two sections, was delivered to the manned complex in the "Kvant" module.

Preparations for the installation work in open space are beginning today. The cosmonauts will inspect the equipment that is necessary for the egress as well as their space suits, and they will work out the procedure for performing the operations on the outer surface of the station.

Two egresses into open space for the purpose of installing the solar panel are planned early in May.

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## MANNED MISSION HIGHLIGHTS

### WORK BEGINS WITH ATTITUDE CONTROL GYROS

Moscow KOMSOMOLSKAYA PRAVDA in Russian 25 Apr 87 p 1

[Article by S. Leskov, correspondent at the Flight Control Center]

[Excerpt] On 23 April at 2105 hours the cargo ship "Progress-29" was docked with the orbiting complex "Mir"--"Soyuz TM-2"--"Kvant," in which cosmonauts Yu. Romanenko and A. Laveykin have been working for more than two months.

Lately at the Flight Control Center, whatever the topic of conversation may be, it always comes around to the question: What was it in fact that interfered with the docking [of the "Kvant"]? Even the direct reports of the dramatic docking of the "Kvant" astrophysical module with the "Mir" orbiting station failed to clarify the matter completely. The cosmonauts were unable to identify the mysterious object in the white wrapping. After it was cut, it floated off into space.

Some Western news agencies are reporting that the cosmodrome launch team was careless and left the ill-fated bag on the module's rod. Although the actual cause is still unknown, this version must be unequivocally rejected. Control photographs taken at the launch site have been received at the Flight Control Center, and they don't show any foreign objects. It appears that we will get a final answer only after the cosmonauts return. In any case, the critical situation is over.

Late in the evening of 23 April, the new "progress" cargo ship approached the orbiting complex. This time, the docking was accomplished without a hitch. All the systems functioned properly.

For the first time, a complex consisting of four objects—"Mir," "Kvant," "Progress-29," and "Soyuz TM-2"—is operating in near-Earth orbit. A real space train!

Specialists at the Flight Control Center now must learn how to operate the power gyroscopes on the complex. Do you remember the spinning top that kids play with? A gyroscope is approximately the same thing, but on the orbiting complex these devices are used for controlling the orientation of the complex. If the speed of rotation is changed, the station turns. No fuel is needed for these maneuvers.

The Flight Control Center has allotted one whole month for mastering the control of the gyroscopes, and this is considered to be a record short time. In time these clever spinning tops will control the station's orientation by means of electronic signals from Earth, but for the time being the help of the station's crew is needed. Every day, the crew will check the rotation by means of a solar sextant. And this must be done with special accuracy, for on the "Kvant," one of the 'coaches' of the space train, there are X-ray telescopes that require highly accurate aiming at stellar objects and keeping a fix on them for a rather long time.

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## MANNED MISSION HIGHLIGHTS

### REVISED PROCEDURE FOR EVA FOR SOLAR PANEL INSTALLATION

Moscow IZVESTIYA in Russian 28 Apr 87 p 3

[Article by A. Ivakhnov, special correspondent at the Flight Control Center]

[Abstract] The article reports on the work that will be involved in the installation of a third solar battery on the "Mir" orbiting complex. This battery is to supply power for flywheels of the "Kvant" astrophysical module's gyroscopes. They are intended for rotating the orbiting complex in order to aim the "Kvant" module's X-ray telescopes and keep a fix on objects of observation.

It is reported that the "Kvant" delivered components of the new solar battery to the "Mir" station, as well as new computer programs for controlling the station's engines. The programs had to be changed because the center of the complex's mass has changed. Plans originally called for the new battery to be installed before the arrival of the "Progress-29" cargo ship, but this operation had to be postponed because of the trouble with the docking of "Kvant." During their space walk to install the battery, cosmonauts Yuriy Romanenko and Aleksandr Laveykin would have to exit through the adapter module of "Mir" and carry the battery's components outside the station. But this module is not large enough to accommodate two men in space suits, the solar battery components, and the bulky structure to which they must be attached. Specialists of the Flight Control Center therefore have devised a plan which calls for the cosmonauts to place the components and their mounting pieces inside the living compartment of the spaceship "Soyuz TM-2." The hatch between the living compartment and the spaceship's re-entry module will be sealed. The hatch between the spaceship's living compartment and the station's adapter module will remain open while they move the gear into the living compartment. Then the crew will seal the hatch of the "Mir" station's working compartment, and will make their egress, using the living compartment of their spaceship as a storage from which to pull out the battery components and other gear as they need them.

It is noted that the first observations with the X-ray telescopes on "Kvant" are scheduled for June, when foreign scientists who took part in developing the instrumentation will arrive in Moscow. A group for controlling the astrophysical module will be created at the Institute of Space Research.

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS COMPLETE TWELFTH WEEK IN ORBIT

Moscow IZVESTIYA in Russian 1 May 87 p 3

[TASS Report]

[Text] Flight Control Center, 30 April. The 12th week of the space mission of Yuriy Romanenko and Aleksandr Laveykin is drawing to a close.

The crew's program of work in the days just past included unloading the unmanned transport ship "Progress-29," arranging the equipment that was delivered, and practicing various modes of orientation and stabilization of the orbiting complex, which consists of four spacecraft. Following preliminary operations for pumping compressed nitrogen out of the fuel tanks of the station's combined engine unit, the crew began refueling them with fuel and an oxidizer.

On 1 May cosmonauts Yuriy Romanenko and Aleksandr Laveykin will rest. On this day they will watch a televised report on the holiday demonstration of workers on Red Square, and they will talk with their families.

According to telemetry data and the reports from orbit, the flight of the manned complex "Mir" is proceeding normally.

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## MANNED MISSION HIGHLIGHTS

### TASS REPORTS POSTPONEMENT OF COSMONAUTS' EVA

Moscow IZVESTIYA in Russian 7 May 87 p 2

[TASS Report]

[Text] Flight Control Center, 6 May. The third month of the space mission of Yuriy Romanenko and Aleksandr Laveykin is coming to an end.

In the course of the mission, the crew has performed scientific-technical studies and experiments which were planned for this period, and they also have done a large amount of work on installing in the base block additional equipment that has been delivered by the cargo ships. The cosmonauts have performed work in open space, taking part in measures to secure the docking of the "Kvant" module with the "Mir" complex.

At the present time Yuriy Romanenko and Aleksandr Laveykin are continuing work on activating the module's onboard systems and checking their functioning, and they are preparing new astrophysical apparatus for operation. At the same time they are busy unloading the "Progress-29" unmanned cargo ship.

Owing to the large volume of different kinds of work that the crew has had to perform, the mission program has been revised, and work in open space which had been scheduled for the beginning of May has been postponed to a later time.

The flight of the "Mir" manned orbiting complex is continuing.

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/8309

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## MANNED MISSION HIGHLIGHTS

### COSMONAUTS CONTINUE RESEARCH, PRACTICE ORIENTATION AND STABILIZATION OF COMPLEX

Moscow IZVESTIYA in Russian 9 May 87 p 1

[TASS Report]

[Text] Flight Control Center, 8 May. The orbital flight of Yuriy Romanenko and Aleksandr Laveykin is continuing.

The cosmonauts are completing work with the unmanned transport ship "Progress-29. They have arranged the delivered items of cargo in rooms of the complex, and they have put depleted equipment in the ship's compartment that was emptied out. At the same time, on commands from the Flight Control Center, tanks of the station's engine unit are being refilled with fuel and oxidizer.

In line with the plan of measures for activating the astrophysical module "Kvant," today the crew will prepare a water-electrolysis system for operation. The system is to serve as an extra source of oxygen on board the manned complex.

In line with the program of geophysical studies, the cosmonauts are making regular observations and are photographing with hand-held cameras separate areas of the Earth's surface. The purpose of these studies is to examine the seasonal development of forest vegetation and agricultural crops, to look for forest fires, and to keep track of meteorological processes in the atmosphere.

Yesterday there was another series of experiments to practice various modes of orientation and stabilization of the multiple-component orbiting complex.

Yuriy Romanenko and Aleksandr Laveykin will enjoy a day of rest on 9 May.

According to telemetry data and the report from orbit, the flight of the manned complex "Mir" is proceeding normally.

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/8309

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## MANNED MISSION HIGHLIGHTS

### TASS REPORTS UNDOCKING AND DESTRUCTIVE REENTRY OF 'PROGRESS-29'

Moscow IZVESTIYA in Russian 12 May 87 p 1

[TASS Report]

[Text] Flight Control Center, 11 May. The flight of the unmanned transport ship "Progress-29," which went into near-Earth orbit on 21 April 1987, has ended.

The cargo ship had docked with the manned complex "Mir" on 23 April. The work that was planned for the period of the joint flight was accomplished in its entirety. It included unloading of cargo items and refueling the station's engine unit and pumping of drinking water.

Today at 0710 hours Moscow time, the "Progress-29" ship separated from the orbiting complex "Mir." Then the ship was oriented and its engine was fired on commands from the Control Center. As a result of braking, the "Progress-29" went into a descending trajectory, entered the dense layers of the atmosphere and ceased to exist.

Cosmonauts Yuriy Romanenko and Aleksandr Laveykin are continuing work on board the scientific research complex "Mir." Today's schedule for the crew calls for routine work on the station and for doing another series of geophysical experiments.

According to telemetry data and the reports from orbit, the flight is proceeding normally.

FTD/SNAP  
/8309  
CSO: 1866/97

IZVESTIYA ON UPCOMING SPACE MISSIONS

Moscow IZVESTIYA in Russian 4 Jan 87 p 3

[Article by Izvestiya correspondent G. Alimov: "Chronicle of Space Premieres"]

[Text] In the coming year, our scientists will take new steps in the peaceful study of outer space. Several impressive projects are now either in a state of total readiness or at some stage of development. The consistency and scope of Soviet space programs are drawing the attention of specialists from around the world. And more important, it can be said about almost all of the projects that they are being done for the first time in the world.

Here is what the research associates at the Institute of Space Research of the Academy of Sciences of the USSR told our correspondent G. Alimov about their work.

A research complex for the "Mir" station will be launched very soon. This will be the first such observatory in orbit. Four powerful telescopes will enable us to study x-ray emissions in a wide spectrum. Specialists from the Federal Republic of Germany, Holland, and the European Space Agency also took part in the project's preparations. The observatory will be docked with the station and will be able to operate automatically or under the direction of an operator.

Extra-atmospheric astronomy is one of the most interesting and rapidly developing fields of research. Before the advent of space and rocket technology, observations of celestial bodies were made with optical and radiotelescopes. Now the possibilities have expanded for scientists. Extremely interesting results were obtained in x-ray astronomy as early as the '60s, when numerous unknown objects were discovered. X-ray emissions carry invaluable information from hot plasma whose temperatures range from a million degrees to tens of millions of degrees and sometimes even to hundreds of millions of degrees. These emissions originate in the vicinity of neutron stars and "black holes." The principal "supplier" of the data on the mysterious processes that take place in "black holes" is x-ray emissions.

The new observatory that will leave for "Mir" will not only help us obtain information on the energy spectra of the x-ray sources and on their



variability in time, but will also help us construct images of them. This experiment is expected to span a year, starting from the day of the launch.

An observatory for the study of gamma emissions in space is completely ready for launch. It was developed in conjunction with French scientists. This project, "Gamma," also has no equal in terms of its aims and possibilities.

Perhaps the most impressive work of the coming years will be the multi-goal project "Phobos." Earth's envoy will conduct research of the sun, interplanetary medium, Mars, and one of its satellites, Phobos, which has an extremely low albedo, which, simply speaking, means it is very black. Some therefore suggest that this satellite of Mars is similar to a meteorite of the class of carbonaceous chondrites. The least-changed of all matter in the solar system, with the exception of comets, they can give us information on the early stages of formation of the planets and of the existence of the solar system.

The spacecraft will approach Phobos and will pass along a given course at a height of about 50 meters. Here on earth, we will receive video images from various distances. Specialists intend to conduct experiments to determine the composition of the soil. This will be done by various means, among them a long-term unmanned station that will land on Phobos. The station is expected to spend about a month there, in constant communication with Earth. It is possible that soil samples will be taken, to determine whether or not it contains volatile substances, like water or organic compounds...

Work on this program is in a stage in which engineering mock-ups are being produced and refined. Serious laboratory tests are ahead. The flight, from all appearances, will take place as early as 1988.

13227

CSO: 1866/51

COMMENTARY ON FUTURE SPACE ASTRONOMY MISSIONS

Moscow TRUD in Russian 25 Oct 86 p 3

[Article by Ye. Nelepo, Research associate at the Institute of Space Research of the Academy of Sciences of the USSR: "The Secrets of the Universe: New Projects of Soviet Scientists"]

[Text] It is difficult to understand and almost impossible to imagine that roughly 15 billion years ago all metagalactic matter, including millions of star clusters, was compressed, in the opinion of many scholars, into a sphere whose radius was only one one-hundredth of a centimeter in all. Smaller than a pin head! Then, according to this hypothesis, the "big bang" occurred. In the first moments after that, the temperature of the matter was the number one with 32 zeros after it. That initial plasma expanded continuously and again absorbed photons -- the elementary particles of electromagnetic radiation. After approximately a million years, the temperature had already fallen to 4,000 degrees, and matter became neutral in its mass and was transformed into a mixture of hydrogen and helium atoms.

As the plasma continued to expand, the radiation became increasingly colder. Now its temperature has fallen to a mere three degrees above absolute zero, that is, about -270 degrees. Its very nature, its spectrum is preserved like a relic, like the "memory" an early period of the evolution of the universe. And what could be more interesting than to get to know the universe past, the Earth past.

Studying the relic radiation, however, has turned out to be extremely difficult -- there is a great deal of atmospheric interference. That is why the "Prognoz-9" satellite was placed in orbit with a highly sensitive radiotelescope on board. The telescope could distinguish between two points on the celestial sphere if their temperatures differed by as little as an amount that measured in the ten-thousandths of a degree. The sensitivity of the radiometer developed by Soviet scientists is, judging by reports in the foreign press, twice as great as a similar instrument that American scientists plan to put into orbit no earlier than 1988.

"Today," says I. Strukov, a department head at the Institute of Space Research of the Academy of Sciences of the USSR, "we are thinking about continuing the experiment. Using special techniques -- cooling the radiation

detector and the antenna, for example -- the sensitivity of the instrument can be increased by a factor of 3 or 4."

Soviet scientists are also working on a project that involves a mammoth radio system that will consist of earth-based and space-based radiotelescopes that operate in synchrony. The telescopes must be launched hundreds of thousands of kilometers into space. A similar system, called an interferometer, makes it possible to obtain images of remote objects in the universe that are a thousand times better than the images we get now. Here it is not the diameter of every individual antenna that is important, but the overall distance between the antennas -- the base of the interferometer.

The space-based radiotelescope antenna is designed to open automatically, with rigid panels that have a composite material base. One of the principal targets of research will be the interior regions of the mysterious quasars -- those exceptionally bright formations. In terms of emissions, each of them is equivalent to an entire galaxy of hundreds of billions of stars! There is reason to believe that quasars are 15 billion light-years away, that is, they are at the edge of the universe as we know it. To study such remote objects is, in fact, to observe the distant past. We will see the circumstances that existed long before the solar system came about, a picture of the events that led up to us from out of an unknown universe.

Radiotelescopes that are lifted into space enable us to study our own planet on a new level. With their help, we will, with the greatest of accuracy, be able to measure the coordinates of specific points on the earth's surface, monitor continental drift, detect phenomena that precede earthquakes, and solve many other scientific and day-to-day problems.

No less interesting is the study of x-ray emissions from space. One of the next Soviet space projects involves the x-ray observatory that is due to be incorporated in the research instrumentation aboard the orbiting station "Mir."

X-ray emissions originate in the "cauldron" of atomic and nuclear transformations that occur in space at temperatures of at least 500,000 degrees. By comparison, one may recall that visible sunlight is emitted by a surface that is heated to "only" five and a half thousand degrees. Thus, in the x-ray spectrum, one can observe the "hottest" and the "most violent" events in the universe.

The multiple-unit x-ray observatory has four primary x-ray telescopes and three auxiliary instruments. Scientists from the USSR, Holland, the Federal Republic of Germany, England, and the European Space Agency took part in their development and manufacture.

In terms of capability and scientific possibilities, it will be at least 1990 before there is another apparatus in the world like this space observatory.

A project involving another orbiting observatory -- it has been named "Granat" -- is being carried out jointly by Soviet and French scientists.

"The observatory will make it possible to determine the temperature of thermal plasma in galaxy clusters, x-ray pulsars, and regions around black holes," says corresponding member of the Academy of Sciences of the USSR R. Syunyayev, the project's scientific director and head of the department of high-energy physics at the Institute of Space Research of the Academy of Sciences of the USSR.

"Granat" must be the largest project in the world for the study of gamma-ray bursts. The history of their discovery is quite interesting. Soon after atmospheric nuclear explosions were banned, the Americans used "Vela" satellites as monitoring posts. Nuclear explosions are known to be accompanied by a powerful surge in gamma emissions. And the detectors on board the monitoring satellites registered bursts of such emissions. The first response of the Americans was that the Russians were violating the agreement. Soon, however, it was ascertained that the bursts were originating from space. Their brightness was striking, sometimes a thousand times greater than that of the strongest of the known stationary cosmic sources.

Observations made from satellites and interplanetary spacecraft have enabled us to come closer to a solution. More than anything else, the sources of the gamma-ray bursts appear to be neutron stars with superstrong magnetic fields. However, several points remain unexplained.

That is why scholars are so eagerly awaiting the gamma-ray-burst research that will be conducted by the orbiting observatory "Granat." The research equipment will be mounted on a revolving platform. That will make it possible to aim the instruments at the source of the gamma-ray burst in a matter of seconds and follow the development of the event precisely.

But it is not just radio and x-ray emissions that come from the depths of outer space. Gamma rays are also riveting the attention of scientists. Experiments involving a prototype of the largest gamma-ray telescope in the world for on-board research on an orbiting observatory were recently performed on a particle accelerator in Troitsk, a city near Moscow. Besides the large primary telescope -- called "Gamma-1" -- it will have two other astronomical instruments -- an x-ray telescope and a soft-gamma-ray telescope.

The project "Gamma-1" is the result of many years of combined work by Soviet and French scientists. The experiments involving satellites and manned orbiting stations were preceded by successful experiments involving initial telescope models carried by balloons in the upper layers of the atmosphere and the development of more refined designs at land-based installations that simulated the conditions of outer space...

After the particle-accelerator experiments on the flight model of the telescope are completed, it will be installed on a spacecraft, and its preparation for launch will begin....

13227  
CSO: 1866/51

'ASTRON' OBSERVATORY SATELLITE COMPLETES FOURTH YEAR IN ORBIT

Riga SOVETSKAYA LATVIYA in Russian 24 Mar 87 p 1

[TASS Report]

[Text] Nauchnyy (Crimea Oblast), 23 March. The astrophysical observatory "Astron" has been operating in a near-Earth orbit for four years. During this time, more than 500 periods of communication have been conducted with the spacecraft, and information has been gathered on distant stars, gaseous nebulae and galaxies.

Placing the flying observatory into an orbit which reaches an altitude of 200,000 kilometers at apogee made it possible to obtain such information. It helped to prevent charged particles from our planet's radiation belts from affecting the spacecraft instruments. The observatory's ultraviolet telescope, the largest of its kind in space, and X-ray telescope-spectrometer plus the automatic devices for aiming the telescopes at objects operate faultlessly in such conditions.

The "Astron" experiment was developed by both Soviet scientists and specialists of France. Programs for observing stellar objects with the aid of the orbiting observatory are being drafted in collaboration with scientists of the Marseilles Space Astronomy Laboratory.

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## PRELIMINARY RESULTS OF SIGNE-2MP9 EXPERIMENT FOR INVESTIGATING COSMIC GAMMA RAY BURSTS

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12, No 10, Oct 86  
(manuscript received 14 Mar 86) pp 745-754

[Article by A.V. Kuznetsov, R.A. Syunyayev, O.V. Terekhov, L.A. Yakubtsev, C. Barat, B. Boer, G. Vedrenne, M. Niel and K. Hurley, Space Research Institute, USSR Academy of Sciences, Moscow; Cosmic Radiation Research Center, France]

[Abstract] The Soviet-French SIGNE-2MP9 experiment was carried out aboard the "Prognoz-9" satellite during the period 2 July 1983-9 February 1984. The SIGNE-2MP9 was developed and fabricated at the Cosmic Radiation Research Center at Toulouse. It consisted of an electronics system and two identical detector groups. The S and AS detector groups for the registry of  $\gamma$ -quanta were situated on the solar and antisolar sides of the spacecraft and had NaI(Tl) scintillation crystals with a diameter of 15.0 cm and a height of 2.0 cm. The axes of symmetry of these crystals were arranged along the axis of station rotation. The instrument operated in "standby" and "burst" modes. A "burst" mode was activated automatically when the counting rate exceeded the background by  $\sim 8$  standard deviations. The total time of instrument operation was 7 months. During this time the instrument registered more than 30  $\gamma$ -bursts and 10 so-called candidates. About 50 events associated with solar flares were also registered. A table lists the events of nonsolar origin. Among these was GRB830801b, one of the strongest ever registered. The percentage of short bursts (those with a duration of less than 1 s) during this experiment was about 40 percent of the total number. Figures 6; references 16: 5 Russian, 11 Western.

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UDC 520.6

POWERFUL GAMMA RAY BURST GRB830801b. SIGNE-2MP9 EXPERIMENTAL DATA

Moscow PISMA V ASTRONOMICHSKIY ZHURNAL in Russian Vol 12, No 10, Oct 86  
(manuscript received 14 Mar 86) pp 755-762

[Article by A.V. Kuznetsov, R.A. Syunyayev, O.V. Terekhov, L.A. Yakubtsev, C. Barat, B. Boer, G. Vedrenne, M. Niel and K. Hurley, Space Research Institute, USSR Academy of Sciences, Moscow; Cosmic Radiation Research Center, France]

[Abstract] A gamma burst was registered by the SIGNE-2MP9 instrument (S detector) on 1 August 1983 (designated GRB830801b). This is the most powerful and hardest of the events detected in the experiment and evidently the most powerful burst detected during the entire history of burst observation (this burst was also registered by the VELA and ISSE-3 spacecraft instruments). The duration of this event was 30 s and the time profile is a smooth curve atypical for  $\gamma$ -bursts due to the absence of a fine structure. A distinguishing feature of this burst was a precursor with a duration  $\sim 0.1$  s; the intensity at its maximum was less than the intensity of the main burst by a factor of 30 and energy release was almost four orders of magnitude less than in the main burst. The flux maximum in the hard energy channels from 4.5 to 7.5 MeV outstripped the flux maximum in the soft region (39-68 keV). The evolution of the burst spectrum could be described in detail, the burst beginning with the emission of high-energy  $\gamma$ -quanta. Energy release was maximum at the beginning of the burst and dropped off rapidly with time, although the number of registered photons remained constant for a relatively long time. Figures 5; references 4: 2 Russian, 2 Western.

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CSO: 1866/29

UDC 629.191

## EQUILIBRIUM CONFIGURATIONS OF ELASTIC RING IN PLANE OF CIRCULAR ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 27 Jun 85) pp 659-667

[Article by Yu. A. Sadov and V.V. Sidorenko]

[Abstract] A study was made of a system formed by an elastic rod bent in the form of a ring whose ends are attached in a material body of a size negligible in comparison with the radius of the ring. It is assumed that the center of mass of the system moves in a circular orbit around the earth. (The difference between the velocity of the center of mass and the velocity of the material point in the corresponding orbit is neglected.) Among all the possible external influences, only gravitational effects are taken into account. The most important parameters considered are  $\alpha$ , the fraction of mass of the elastic rod in the total mass of the system (if the mass of the rod is negligible in comparison with the mass of the material point to which the ends of the rod are attached,  $\alpha = 0$ ). The  $\beta$  parameter defines the degree of compliance of the ring to gravitational gradient forces (if ring rigidity is great,  $\beta$  is small, but a small flexural rigidity corresponds to large  $\beta$  values). Analytical and numerical methods were used in study of the configurations formed by the deformed rod corresponding to the position of equilibrium in an orbital coordinate system. It is assumed that the plane of the ring coincides with the orbital plane and that the inertial characteristics satisfy the conditions of stable gravitational orientation of the system as a solid body. Some characteristics of equilibrium configurations (area bounded by the ring, linear dimensions of the construction, elastic reactions at points of rod attachment in the body) are determined. Figures 4, references: 6 Russian.

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CSO: 1866/32

UDC 629.785

## OPTIMIZING CHOICE OF MEASUREMENT TIMES AND NAVIGATIONAL STARS IN PROBLEM OF AUTONOMOUS NAVIGATION OF SPACECRAFT USING UNKNOWN REFERENCE POINTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 14 Oct 85) pp 668-679

[Article by M. I. Vinokur]

[Abstract] The guaranteed evaluation of the error in determining a scalar orbital parameter when measuring the angles between the directions from a spacecraft to unknown reference points on the surface of a planet and to known stars is minimized for plane and three-dimensional cases without allowance for planetary rotation. (By the term "unknown reference point" is meant a fixed point on the planetary surface whose planetocentric coordinates are known in advance aboard the spacecraft with an error which cannot be disregarded.) Tables 1-3 give the errors in determining the orbital elements  $T$ ,  $\tau$ ,  $\omega$  of a vehicle of the "Molniya-1" type when using 1, 2, 3 and 4 reference points, errors in determining  $r$  and  $m$  for a low quasicircular orbit when using 1, 2, 3 and 4 reference points and errors in determining the orbital elements  $T$ ,  $\tau$ ,  $\omega$  of a vehicle of the "Molniya-1" type for different numbers  $s$  of reference points and  $k_0$  of stars ( $\tau$  is the time of passage through pericenter;  $\omega$  is the argument of pericenter latitude,  $r$ ,  $m$  are projections of the radius vector  $r$  of the spacecraft onto the radius vector  $\underline{r}_0$  and transversal  $\underline{m}_0$  of the reference orbit). Formulas are derived which can be used in solving the problem on a computer by the linear programming and multidimensional random search methods. All computations were made on a BESM-6 computer using programs written in FORTRAN. Numerical results are given for an elongated circumterrestrial orbit and for a two-parameter family of circumterrestrial orbits close to circular. Figure 1; references: 7 Russian.

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CSO: 1866/32

UDC 551.510.53

## ROLE OF MASS TRANSFER IN HIGH-LATITUDE UPPER ATMOSPHERE DURING POLAR NIGHT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 21 Aug 95) pp 711-717

[Article by G.F. Tulinov, M.N. Vlasov, V.Ye. Davydov and A.A. Pokhunkov]

[Abstract] The objective of the study was the integration of model representations and experimental data for analyzing the role of mean mass transfer and corpuscular dissociation processes, photochemical properties, turbulent mixing and molecular diffusion in forming the distribution of the principal components of the upper atmosphere during the polar night. The basis for the work was the results of measurements of the  $[O]/[O_2]$  ratio made at Kheys Island ( $80^{\circ}35'N$ ). The authors compare the results of these rocket experiments with corresponding measurements of vertical profiles of the  $[O]/[O_2]$  ratio at the equator and in the middle latitudes under quiet geomagnetic conditions (such a comparison is made for the first time). Figures 1-4 show these vertical profiles measured in the cusp, polar cap and equatorial zone, vertical profiles of probability of dissociation for different leaking particles, computed vertical profiles of atomic oxygen in the polar region and computed vertical  $[O]/[O_2]$  distributions in the polar region. It was found that the values of this ratio during the polar night (when there is virtually no solar dissociating radiation) are very close to the corresponding values observed at the equator and in the middle latitudes. An analysis of these results on the basis of a theoretical model of upper atmosphere composition, taking into account the diffusion of all three principal components ( $O$ ,  $O_2$  and  $N_2$ ), turbulent mixing, photochemical processes and mean mass transfer indicated that the dissociation of  $O_2$  due to corpuscular streams in the polar region cannot account for the registered high  $[O]/[O_2]$  ratios. However, these ratios can be reproduced in a theoretical model by introducing a downward-directed mean mass transfer with rates which are known not to exceed those observed in the middle latitudes. Figures 4; references 12: 7 Russian, 5 Western.

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UDC 523.037:525.7

FLUXES OF ELECTRONS WITH  $E > 10$  MeV AND PROTONS WITH  $E \approx 400$ -1200 MeV IN  
BRAZILIAN (SOUTH ATLANTIC) ANOMALY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 20 Nov 85) pp 718-724

[Article by L.V. Kurnosova, L.A. Razorenov and M.I. Fradkin]

[Abstract] An effort was made to clarify the nature of the high-energy electrons which are observed at altitudes 200-300 km in such regions as the Brazilian anomaly. The data used were from the "Cosmos-555" satellite for the period April-May 1973. The measurements were made with a Cerenkov-scintillation telescope whose axis was vertically oriented; telescope angular aperture was  $\sim 90^\circ$ . Measurements were made of the counting rate of coincidences of signals in the Cerenkov counter and in the scintillator for two threshold levels. The counting channel with a low threshold could register protons with an energy  $E_{kin} > 400$  MeV, whereas the channel with a high threshold could register protons with an energy  $E_{kin} > 1200$  MeV. Both channels could also register electrons with  $E > 10$  MeV. In the Brazilian anomaly the counting rate in both channels increased. In the anomaly the ratio of the flux of trapped electrons with  $E > 10$  MeV at altitudes  $\sim 240$  km to the flux of protons which can generate them is  $(5.5_{-2.2}^{+0.9}) \cdot 10^{-3}$ , which is consistent with a model of formation of trapped electrons in the anomaly by decay of  $\pi^\pm$ -mesons generated by belt protons. The flux of albedo electrons with  $E_e > 10$  MeV emanating from the earth at an altitude  $\sim 240$  km differs little from the mean return albedo flux at the same L shells. Figures 3; references 10: 9 Russian, 1 Western.

5303/8309

CSO: 1866/32

UDC 523.72

BEHAVIOR OF KINETIC PARAMETERS OF PROTONS AND  $\alpha$ -PARTICLES AS FUNCTION OF SOLAR WIND VELOCITY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 11 Apr 86) pp 725-734

[Article by Yu. I. Yermolayev]

[Abstract] An energy and mass spectrometer on the "Prognoz-7" satellite was used in collecting data for studying the behavior of the kinetic parameters of protons and  $\alpha$ -particles with a change in the velocity of the solar wind, for evaluating the role of Coulomb collisions in smoothing the differences in velocities and temperatures of protons and  $\alpha$ -particles with a change in velocity of the solar wind and for comparison of the results with those from a similar experiment on the ISEE-3 vehicle made approximately during the same period. It was found that in agreement with estimates made in other experiments the temperature  $T$  and concentration  $n$  change with a change in velocity  $v_p$  of the solar wind in general in conformity to a power law with an exponent  $\sim 2.5$  for temperature and  $\sim -2$  for concentration, indicating conservation of the density of kinetic energy of the solar wind with a change in its velocity. The difference in the velocities of  $\alpha$ -particles and protons  $v_\alpha - v_p$  increases monotonically with an increase in  $v_p$  from  $\sim -5$  km/s with  $v_p \approx 300$  km/s to  $\sim 20$  km/s with  $v_p \approx 620$  km/s. The ratio of the temperatures of  $\alpha$ -particles and protons  $T_\alpha/T_p$  increases monotonically with an increase in  $v_p$  from  $\sim 1$  with  $v_p \approx 300$  km/s to  $\sim 4$  with  $v_p \approx 450$  km/s and with a further increase in  $v_p$  retains a value about 4. Coulomb collisions can equalize the velocities and temperatures of  $\alpha$ -particles and protons in the slow solar wind. It is noted that the results obtained using the mass spectrometer on the ISEE-3 for the solar wind velocity range  $v_p = 550-670$  km/s contain a methodological error in determining the kinetic parameters of  $\alpha$ -particles. Figures 4; references 20: 5 Russian, 15 Western.

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CSO: 1866/32



UDC 550.37

ELECTROMAGNETIC FIELD OF LOOP ANTENNA SITUATED IN COLD MULTICOMPONENT  
MAGNETICALLY ACTIVE PLASMA (IONOSPHERE)

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 15 Jul 85) pp 735-744

[Article by A.V. Moshkov]

[Abstract] The electromagnetic field at an arbitrary distance from a loop antenna situated in cold homogeneous collisional multicomponent magnetically active plasma was investigated in a linear approximation on the basis of an expansion in plane waves. Analytical expressions for quasistatic near fields are derived applicable to an elementary loop. It was found that the quasistatic near magnetic field of a loop antenna is not dependent on plasma parameters. The low-frequency near electrical field of an elementary loop with  $f > f_{LHR}$  has a sharply expressed maximum attributable to the influence of plasma resonance. In the case of a source of finite dimensions the field strength in the neighborhood of the resonance direction can substantially change. Expressions suitable for numerical integration on a computer are derived for field strength computations at an arbitrary distance from the source. The results of computations of the field of a low-frequency loop antenna in the ionosphere are given as an illustration. It was found that in a space experiment the field strength at a distance of several wavelengths from the source is determined for the most part by the component of the loop moment along the direction of the geomagnetic field. Figures 4; references 11: 6 Russian, 5 Western.

5303/8309

CSO: 1866/32

UDC 537.12+550.388.2

## TRANSVERSE ELECTRICAL CURRENTS IN AURORAL MAGNETOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 4 Mar 85) pp 745-750

[Article by V.A. Lipеровskiy, M.I. Pudovkin, S.S. Sazhin and S.L. Shalimov]

[Abstract] At altitudes greater than 500 km in the magnetosphere, collisions of ions and electrons with neutral particles are extremely rare and since transverse Pedersen conductivity is virtually equal to zero, the transverse Pedersen current in the presence of a transverse electrical field should also be equal to zero. This conclusion, however, is contradicted by both direct and indirect experimental data. Accordingly, an analysis was made of the transverse currents in turbulent plasma in the presence of well-developed EIC turbulence at the mentioned altitudes. The study was restricted to a study of the existence of EIC turbulence alone, although the development of other types of turbulence on auroral lines of force is possible. Full allowance was made for research carried out earlier on this problem. The analysis revealed that an allowance for the nonuniformity of magnetospheric plasma during the flowthrough of a longitudinal current with a current density adequate for the generation of EIC turbulence results in the simultaneous generation of a transverse current and the partial short circuiting of the longitudinal current by the transverse current. The combination of two effects, plasma nonuniformity and plasma turbulence, can explain the observed partial short circuiting. References 21: 11 Russian, 10 Western.

5303/8309

CSO: 1866/32

UDC 523.72

## NONSTATIONARY PHENOMENA NEAR TAIL OF EARTH'S MAGNETOPAUSE ASSOCIATED WITH RECONNECTIONS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 22 Jul 85) pp 751-761

[Article by A.N. Omelchenko]

[Abstract] A study was made of phenomena in the tail part of the magnetopause associated with reconnections which occur in a limited region in the neighborhood of the cusp. The analysis was based on data obtained by a number of satellites and new conclusions were drawn concerning the plasma mantle in the northern hemisphere in the sector approximately 0000-0600 MLT. A series of spectra similar to the spectra observed earlier under the magnetopause in disperse plasma bursts were detected in the transition region adjacent to the tail part of the earth's magnetosphere. A disturbed zone, characterized by a two-peak flux velocity distribution, was found in the transition region adjacent to the magnetopause. These two phenomena are observed when there is a negative  $B_y$  component of the interplanetary magnetic field in the mentioned sector. Long-period oscillations of the magnetopause may be caused by reconnections in the tail lines of the magnetosphere. These oscillations initiate the already mentioned phenomena and have the nature of a surface wave which propagates through the magnetopause. These surface waves generated by reconnections may have a global character and exert an influence on oscillations of the entire magnetospheric tail. There are phenomena indicating reconnections occurring in the tail part of the magnetopause which can be detected both under the magnetopause and in the transition region. These phenomena may exert a significant influence on the entire tail part of the magnetosphere. Figures 7; references 18: 7 Russian, 11 Western.

5303/8309

CSO: 1866/32

UDC 537.591

VARIATIONS IN INTENSITY OF FLUX OF RELATIVISTIC ELECTRONS IN ORBIT OF  
GEOSTATIONARY ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 22 Oct 85) pp 762-769

[Article by I.P. Bezrodnykh, Ye.I. Morozova and Yu.G. Shafer]

[Abstract] The intensity of the flux of electrons with energies  $E_e = 1-1.5$  and  $\geq 2$  MeV was measured in the outer radiation belt by the instruments aboard the "Raduga-1" and "Raduga-2" geostationary satellites (85.5°E and 35°E) during the increase phase of the 21st solar activity cycle. The objective of the experiment was registry of the periodic and aperiodic components of the flux of outer belt relativistic electrons. The flux of these electrons is characterized by sharp changes. The time profile of the electron flux is characterized by group of individual bursts at whose maximum the energy spectrum is hardest. During the period 1977-1979 the instruments registered about 50 powerful bursts of electron intensity with a duration up to 7 days and an amplitude exceeding the mean background level by a factor of 5 or more. Spectral analysis was used in discriminating variations with periods of about 7, 15, 27 and 30 days and about 6 and 13 months. The observed increases in the intensity of relativistic electrons are a response to increase in solar wind velocity. For example, variations with periods of 7 and 15 days are caused by passage of interplanetary magnetic field structures. Electron variations with a period of 13 months are probably associated with periodic change in the flux density of relativistic electrons in interplanetary space (13 months is the synodic period of rotation of Jupiter, the source of relativistic electrons). Figures 5; references 19: 9 Russian, 10 Western.

5303/8309

CSO: 1866/32

UDC 543.42:522.124

FLUX OF NUCLEI WITH ENERGY OF SEVERAL HUNDRED MeV/NUCLEON MEASURED IN  
'SALYUT-6' ORBITMoscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 11 Nov 85) pp 770-777[Article by K. Blaj, V.V. Bobrovskaya, G.P. Gertsen, N.L. Grigorov, M. Zhobanu,  
A.M. Marennyy, A. Marin, R.A. Nymnik, A.V. Solovyev, M. Khayduk and  
D. Khashegan]

[Abstract] The latitudinal distribution of a flux of nuclei with an energy of several hundred MeV/nucleon was measured in the orbit of the "Salyut-6" during the period 17-21 May 1981. The measurements were made with the "Astro-2" instrument in which nitrocellulose detectors move cyclically relative to one another (Fig. 1 is a block diagram of the instrument and serves as a basis for the textual description). Most of the registered particles are nuclei with  $Z \geq 20$ , within the station having an energy up to 250 MeV/nucleon. A total of 760 pairs of tracks were detected by the four sets of detectors. These observations were compared with computations of the distribution of iron nuclei with an energy 250-430 MeV/nucleon by geographical latitudes. Significant differences were found between the computations and experimental data. These differences can be reconciled if it is assumed that the particles penetrating to the orbit have a magnetic rigidity twice as great as assumed in the computations. It appears that the charge composition and distribution of particles registered by energies in the region of geographical latitudes less than  $40^\circ$  do not differ from these flux characteristics at latitudes greater than  $40^\circ$ . No final solution of the problem is possible without a detailed examination of geomagnetic field configuration. Figures 4; references 16; 11 Russian, 5 Western.

5303/8309

CSO: 1866/32

UDC 523.72:523.42

## SOME ASPECTS OF FLOW OF SOLAR WIND AROUND VENUS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 6 Sep 85) pp 778-786

[Article by A.M. Krymskiy and T.K. Breus]

[Abstract] Analytical estimates of "loading" of the solar wind flux by hot oxygen ions forming during photoionization of the oxygen corona of Venus are given. The measurements were made on the Pioneer-Venus spacecraft. The influence of this effect on the parameters of plasma flow in the frontal region behind the bow shock was studied and the stability of the ionopause was analyzed with axial symmetry of the flow taken into account. Section 1 outlines an analytical model of the plasma flow in the transition region with allowance for the effect of loading of the solar wind flux with ions of planetary origin. The influence of loading on the position of the bow shock and magnetic field strength in the magnetic barrier is estimated. Section 2 gives an analysis of the possibility of development of Kelvin-Helmholtz instability in the frontal part of the transition region of Venus. It was found that loading of the solar wind increases the distance between the bow shock and the ionopause and the maximum strength of the magnetic field in the magnetic barrier in the neighborhood of the frontal point decreases. Axial symmetry of the flow leads to ionopause stability in the frontal part ( $\theta \leq 10^\circ$ ) relative to perturbations with  $\lambda \geq 50$  km. For shorter wavelengths a study of stability should be accomplished numerically and the stabilizing influence of the terminal Larmor radius of ions must be taken into account. Although there is good qualitative agreement with magnetohydrodynamic theory, three effects must be taken into account: turbulence effect, terminal Larmor radius of ions and collisions with neutral particles. References 24: 7 Russian, 17 Western.

5303/8309

CSO: 1866/32



UDC 581.521

INFLUENCE OF ELECTRON HEATING ON LONGITUDINAL VELOCITIES OF  $O^+$  IONS IN MAGNETIC TUBES OF FORCE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 14 Mar 86) pp 787-791

[Article by S.A. Grigoryev, L.V. Zinin and K.S. Latyshev]

[Abstract] An attempt was made to clarify the influence of electron heating on the longitudinal velocities of  $O^+$  ions in magnetic tubes of force. The physical formulation of the numerical experiment was roughly as follows: electron heating briefly (about 10 minutes) occurred in a magnetic tube of force with a steady (stationary) regime (similar to the polar wind for  $H^+$  ions) and a study was then made of relaxation processes from the determined perturbed vertical distribution of concentrations, velocities and temperatures of ions. The self-consistent model used made possible a correct allowance for the influence of electron heating on the longitudinal velocities of  $O^+$  ions in the high-latitude geomagnetic tubes of force. A series of figures shows the results of model computations: spatial profiles of longitudinal velocities of  $O^+$  ions, temporal profiles of relative concentration of  $O^+$  ions at different altitudes, temporal profiles of longitudinal velocity of  $O^+$  ions at different altitudes. It was found that under the influence of nonstationary electron heating there can be considerable upward-directed fluxes of  $O^+$  ions comparable to the fluxes of  $H^+$  ions in the polar wind. The existence of considerable fluxes of thermal  $O^+$  ions in the region of the daytime polar cusp has been revealed by recent satellite measurements. A decisive role in the formation of such fluxes is probably played by nonstationary processes leading to the appearance of nonstationary pressure gradients and therefore a complete restructuring of the dynamic regime of flow of  $O^+$  ions. Similar processes of the transfer of  $O^+$  ions into the magnetosphere can apparently occur in the auroral zone as well. Figures 3; references 20: 3 Russian, 17 Western.

5303/8309

CSO: 1866/32

UDC 551.510:535.4

INTERPRETING MEASUREMENTS OF ATMOSPHERIC ABSORPTION OF 1216 A EMISSION ON  
'INTERCOSMOS' SATELLITES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 5 Jul 85) pp 791-793

[Article by V.A. Krasnopol'skiy]

[Abstract] The emission  $L_{\alpha}$  1216A is absorbed in the atmosphere by molecular oxygen. However, a high percentage of the measured profiles (dependence of atmospheric transmission on sighting altitudes) exhibits considerable absorption at altitudes greater than 120 km where according to the CIRA-1972 model there should be little  $O_2$  absorption. Most such profiles have been registered in winter. The excess in comparison with the CIRA-1972 model can be as great as by a factor of 20. In order to resolve this discrepancy various authors have attempted to attribute this excess to NO or  $H_2O$ . These hypotheses are questionable and dictated a reexamination of existing concepts concerning composition of the upper atmosphere at altitudes 120-170 km. This was done by reinterpretation of  $L_{\alpha}$  measurements made on "Intercosmos" satellites. Computations were made using more precise data on solar radiation and  $O_2$  absorption sections. This reanalysis of the data made it possible to explain the measurements of atmospheric absorption in the considered region as registered by the "Intercosmos" satellites without postulating anomalously high  $H_2O$  or NO concentrations. Figures 2; references 14: 1 Russian, 13 Western.

5303/8309

CSO: 1866/32

UDC 523.037:525.7

VERTICAL DISTRIBUTIONS OF ELECTRIC FIELD AND CONDUCTIVITY IN POLAR IONOSPHERE  
BASED ON MEASUREMENTS ON METEOROLOGICAL ROCKET ON 10 MARCH 1979Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 11 Apr 84) pp 794-795

[Article by I.M. Lopayev, N.I. Lebedev and N.K. Osipov]

[Abstract] The electrodynamic vertical structure of the polar ionosphere is described for a period of magnetic disturbance (10 March 1979) on the basis of rocket sounding data for Kheys Island in the Franz Josef Land Archipelago. An MR-12 meteorological rocket was launched at 1843 hours during the magnetic storm recovery phase. During the sounding period the station was situated in the polar cap. The rocket trajectory was virtually vertical with an apogee at 185 km. The following data were analyzed: measured vertical variation of electric field; Pedersen ( $\sigma_p$ ) and Hall ( $\sigma_H$ ) conductivities computed from the measured electron concentration and the magnetic field; measured vertical variation of electron concentration. The electric field during the observation period averaged 50 mV/m (local maxima at altitudes  $\sim 130, 140$  and 160 km. The direction of the electric field changes along the trajectory. The field at altitudes  $\sim 120$  km has an easterly direction relative to the geomagnetic meridian, but at great altitudes is turned up to  $25^\circ$  westward relative to the geomagnetic meridian. At altitudes 118-122 km there was a boundary between the regions of predominance of Hall and Pedersen conductivities. In the region where Hall conductivity predominates, the electric field is virtually not dependent on the vertical variation of the components of the conductivity tensor, whereas in the region of predominance of Pedersen conductivity there is an anticorrelation between the electric field and conductivity (the local field maxima coincide with the minima in the vertical conductivity distributions). The local vertical changes in field direction relative to the geomagnetic meridian are related to the ratio of local conductivities. This vertical structure of the electric field and conductivity is responsible for the complex structure of auroral electric currents over the polar cap and corresponds to a magnetospheric origin of the electric field, at least at altitudes greater than 120 km. Figure 1; references: 4 Russian.

5303/8309

CSO: 1866/32

UDS 551.521.8

INFLUENCE OF PARAMETERS OF INTERPLANETARY SPACE ON DYNAMICS OF ELECTRONS  
WITH ENERGIES 0.3-3 MeV IN TRANSITION REGIONMoscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 25 Jul 85) pp 795-799[Article by Ye.S. Spirkova, P.I. Shavrin, M.N. Shulenina, B.Yu. Yushkov and  
Yu.V. Mineyev]

[Abstract] Fluxes of high-energy electrons ( $E_e = 0.3-3$  MeV) were registered by the "Prognoz-4" using a differential spectrometer (22 December 1975-mid-March 1976). The magnetopause was intersected head-on on the descending branch of the orbit at latitudes  $35^\circ \leq \varphi_{sm} \leq 50^\circ$  and obliquely on the descending branch  $60^\circ \leq \varphi_{sm} \leq 75^\circ$  (sm is a solar-magnetic coordinate system). The observation corresponded to the deep minimum of the 20th solar activity cycle. The geomagnetosphere was subjected to the influence of recurrent increased fluxes of charged particles and interplanetary shock waves. Figures 1 and 2 show the correlation between the maximum amplitudes of electron bursts at the magnetopause, solar wind velocity and  $K_p$  index values and spectra at the maxima of electron bursts. The experimental data revealed the presence of a correlation between the intensity of bursts of high-energy electrons in the transition region and the velocity of solar wind plasma. The dynamics of the fluxes of high-energy transition region electrons defined by this analysis can be comprehended in the light of existing concepts concerning the nature of the layer of these electrons. Bursts in the layer are formed in the process of acceleration of the high-velocity part of the thermal electrons during their convective transfer along the layer of shear flow of plasma. The several correlations defined in this study support a mechanism of frictional acceleration of solar wind plasma electrons to relativistic velocities. Figures 3; references 11: 10 Russian, 1 Western.

5303/8309

CSO: 1866/32

UDC 629.7

MAGNETIC ORIENTATION OF SATELLITE WITH SPHERICAL DAMPER

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 31 Oct 85) pp 803-815

[Article by V.A. Sarychev and M.Yu. Ovchinnikov]

[Abstract] A strong magnet in a spherical magnetic damper can be used to orient a satellite along the geomagnetic field intensity vector. If the dipole moment of the magnet installed on the float of the damper is properly selected, it will track the motion of the vector  $H$ , thus magnetically orienting the satellite. Assuming that the satellite is a solid and that the moments of inertia of the damper float are negligible in comparison to the moments of inertia of the satellite, the motion of the float around its center of mass does not influence the inertial characteristics of the satellite. The equations of motion of the satellite and float are derived. Results are presented from numerical computations, and the stability of the solutions obtained is investigated. Figures 6; references 11: Russian.

6508/8309

CSO: 1866/47

ROTATION OF SATELLITE WITH GREAT MAGNETIC MOMENT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 9 Aug 85) pp 816-820

[Article by M.L. Pivovarov]

[Abstract] A satellite can be oriented by the interaction of its magnetic field with that of the earth. The planar problem, significantly simpler than the three-dimensional problem, includes the basic disturbances of magnetic field stabilization as a satellite moves in near-polar orbit, and is utilized in this analysis of the motion of a satellite in elliptical orbit, assuming that the satellite has great magnetic moments. The evolution of oscillations and rotations of the satellite with respect to the lines of force of the terrestrial magnetic field is studied. It is found that the system can transit from oscillations to rotations and back. Figures 3; references 5: Russian.

6508/8309

CSO: 1866/47



UDC 531:521.1

ROTATION OF SATELLITE ABOUT ITS CENTER OF MASS UNDER INFLUENCE OF LORENTZ FORCES AT RESONANCE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 24 Jun 85) pp 821-825

[Article by G.V. Lyakhovka]

[Abstract] A previous study determined the projections of the moment of Lorentz forces with respect to the center of mass on the axis of a perigee system of coordinates for a dynamically symmetrical satellite assuming that the terrestrial magnetic field is a magnetic dipole field. This article studies the motion of a satellite surrounded by an electrostatic spherical shield in circular equatorial orbit relative to its center of mass, assuming that the angular velocity of precession of the satellite about the kinetic moment vector is close to the angular velocity of its rotation in orbit. It is shown that the rotation of the satellite due to Lorentz forces is qualitatively similar to the case of motion of the satellite in a gravitational field. References 3: Russian.

6508/8309  
CSO: 1866/47

UDC 629.197.2

ALGORITHM FOR MEAN-SQUARE ESTIMATION OF ORIENTATION OF SPACECRAFT AND ITS  
ERRORS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 16 Jul 84) pp 826-830

[Article by M.Yu. Katargin]

[Abstract] An algorithm is presented for estimation of the orientation of spacecraft, based on a matrix, the columns of which contain the direction cosines of the observed stars from the star catalog, plus a matrix of the same structure containing the direction cosines of the same stars as measured by star sensors onboard the spacecraft. The purpose of the algorithm is to determine the orthogonal matrix called the estimate of spacecraft orientation which minimizes the sum of squares of residual discrepancies. The problem is solved by the method of least squares. The algorithm produced is fast acting and has no computational singularities. Finite equations for determination of the dispersion of error estimate of the algorithm are derived. The dispersion of the angle of the total orientation estimate error is found to depend only on errors of the sensors and the observed star configuration. References 5: 4 Russian, 1 Western.

6508/8309  
CSO: 1866/47

UDC 629.78.015.001

METHODS OF INCREASING ACCURACY OF NAVIGATIONAL DEFINITIONS OF USERS USING  
SPACE RANGE-DIFFERENCE SYSTEMS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 6 Mar 84) pp 831-843

[Article by S.D. Silvestrov, M.P. Nivolko and V.V. Kulnev]

[Abstract] Operation of systems such as the NAVSTAR satellite system is described. Error sources in the range-difference mode are noted. Methods of differential navigation based on the properties of space-time invariance of errors of navigational determinations are described. The summary-range measurement method of measuring spacecraft coordinates when space navigational systems are used is described. The potential accuracy of this method is greater than that of the range-difference method since this method reduces the number of parameters which must be determined, thus reducing the bandwidth of navigational filter frequencies. The point on the Earth influences the change in partial derivatives of the total range with respect to the parameters defined, and can thus be considered in some sense an additional navigational satellite. The summary range method is more resistant to changes in elevation angle of the satellite. The method allows a decrease in the number of channels of user apparatus, but does place additional requirements on user apparatus due to the delay of the signal in the relay hardware, which can be compensated in part by calibration of the delay and proper relay frequency band selection. Figures 6; references 3: 1 Russian, 2 Western.

6508/8309

CSO: 1866/47

PINCHING OF LONGITUDINAL CURRENTS AS A POSSIBLE MECHANISM FOR FORMATION OF  
RAY-SHAPED AURORAS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 27 Aug 86) pp 865-874

[Article by Yu.I. Galperin, L.M. Zelenyy and M.M. Kuznetsova]

[Abstract] The characteristic transverse scale of current fibers in the polar aurora is described. The thinnest rays observed with the adapted eye and binoculars by the authors are bright, narrow filaments of light on the order of 100 m thick, flashing for a few tenths of a second within a larger structure extended along the terrestrial magnetic field. Mechanisms responsible for the development of rays include geometric twisting of auroral sheets into a fold, previously described in detail. Results from the Soviet-French ARKAD-3 project have revealed the minimum characteristic scale of intensive longitudinal currents also on the order of 100 m. A previous work indicated the possibility of breakdown of sheet currents into fibers as a result of instabilities leading to the formation of magnetic islands. This work analyzes the process of pinching of longitudinal sheet currents in order to study the possibility that this way may explain the formation of the ray forms of polar auroras. A possible scenario is presented for breakdown of a homogeneous arch into rays, associated with a stable pressure drop in the plasma layer with resultant two-sheet current structure causing rapid separation of the current layer into fibers or rays. References 39: 15 Russian, 24 Western.

6508/8309

CSO: 1866/47

DIFFUSE AURORAL ZONE. VIII. EQUATORIAL BOUNDARY OF DIFFUSE ZONE OF  
PRECIPITATION OF AURORAL ELECTRONS IN MORNING SECTOR

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 16 Jul 86) pp 875-883

[Article by T.Ye. Valchuk, Yu.I. Galperin, L.M. Nikolayenko, Ya.I. Feldshteyn,  
Zh.M. Boske, J.A. Sauvaul and J. Crasnier]

[Abstract] Diffuse precipitation of auroral electrons occurs in a band located toward the equator from the auroral oval. The location of the equatorial boundary of diffuse injection has been previously studied. This article presents results of determination of the invariant latitude of the boundary based on observations by the Aureole-2 and Aureole-3 satellites. The significance of conditions in the interplanetary medium is discussed, and the positions of the boundary are compared with theoretically calculated positions. The boundary coincides within 100 km with the polar wall of the main gap in the evening subauroral F area. Figures 2; references 25: 5 Russian, 20 Western.

6508/8309

CSO: 1866/47

UDC 581.521

## DYNAMICS OF ENERGY SPECTRA OF ELECTRONS (30-210 keV) DURING GEOMAGNETIC DISTURBANCES BASED ON COSMOS-900 SATELLITE DATA

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 16 Oct 86) pp 896-908

[Article by A.V. Dronov, A.S. Kovtyukh and E.N. Sosnovets]

[Abstract] Results are presented from studies based on data from the Cosmos-900 satellite of differential spectra, the spatial and angular structure of streams of electrons with energies of 30-210 keV in the evening-night (17-23:00) and morning-day (5-13:00) hours during two geomagnetic storms on 6-8 April and 29 July 1977. The data indicate that injection of electrons during the storms was accompanied by their acceleration and pitch-angle diffusion. The relationship and sequence of development of these two processes are studied. In contrast to magnetically quiet periods, during active periods the variation in space, energy and angular distribution of electrons at these energy levels at low altitudes is found to be largely determined not only by pitch-angle diffusion processes, but also by acceleration processes. A new method is developed for analysis of experimental data, and is used to determine the time variation in phase of electron stream intensity as a function of energy. The pitch-angle diffusion factor is found to increase with a decrease in equatorial pitch angle of the electrons. The anomalous variation in electron stream anisotropy in the area of the internal boundary of increased quasi capture electron stream intensities is related to a threshold of cyclotron instability energy. During storms the streams of energetic electrons in the day portion of the radiation belts are found to destabilize. A new mechanism is suggested for formation of the maximum in the electron spectrum at 50-80 keV as a result of convective losses of low energy electrons in the day portion of the magnetosphere. Figures 4; references 21: 8 Russian, 13 Western.

6508/8309  
CSO: 1866/47



UDC 581.521

## STUDIES OF ION COMPOSITION IN GEOSTATIONARY ORBIT. PRELIMINARY RESULTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 2 Jun 86) pp 909-916

[Article by T.Ya. Belousova, N.A. Vlasova, M.F. Foryainov, Yu.V. Kutuzov, M.P. Panasyuk, S.Ya. Reyzman, I.A. Rubinshteyn, E.N. Sosnovets, O.S. Grafodatskiy, A.G. Kozlov and B.N. Kiyazev]

[Abstract] On 18 January 1985, a "Gorizont" communications satellite carrying instrumentation including an ion spectrometer was placed in geostationary orbit. This article presents results of preliminary analysis of experimental data resulting from recording of ion flux in the energy ranges of tens to hundreds of kiloelectron volts obtained for the first time for a quiet period and during a mild geomagnetic storm in geostationary orbit. The results analyzed relate to February-March 1985, a period including several mild geomagnetic disturbances, including a moderate geomagnetic storm of 27-28 February. The data indicate complex processes occurring in the vicinity of the satellite. The strongest variations in ion composition were observed during the major phase and the beginning of the recovery phase and were probably related to multiple impulse injection of particles. The absence of multiply charged ions and the recording of powerful fluxes of  $H^+$  and  $[N, O]^{2+}$  during the main phase of the storm indicate the ionospheric source of the particles injected. The variations in the  $[N, O]^{2+}/H^+$  and  $[C, N, O]^{4+}/H^+$  ratios during the storm are quite similar in form to the change in amplitude of  $D_{ST}$ , a possible result of the adiabatic variation in ion flux with significantly different spectral forms. The rapid destruction of injected ionospheric  $H^+$  and  $O^{2+}$  ions during the storms is in agreement with the estimation of their half-life. The monotonic decrease in the  $[N, O]^{2+}/[C, N, O]^{4+}$  ratio from 25 February through 7 March may be explained by quasi-steady pumping of multiply charged ions of solar origin into the radiation belts and their gradual recombination during moderate geomagnetic activity. Figures 4; references 9: 3 Russian, 6 Western.

6508/8309

CSO: 1866/47

UDC 550.383

INTERPLANETARY SHOCK WAVE OF 1 FEBRUARY 1982: MAGNETIC STRUCTURE AND INTER-  
PLANETARY MAGNETIC FIELD POWER SPECTRUM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 18 Nov 85) pp 917-925

[Article by Ye.I. Morozova, L.V. Yevdokimova, Ye. Yu. Budnik, Ye.G. Yeroshenko,  
I.P. Bezrodnykh, N.F. Pisarenko, V. Ridler and K. Shvingenshu]

[Abstract] The evolution of the interplanetary magnetic field power spectrum behind the leading edge of the interplanetary shock wave on 1 February 1982 is analyzed. Data were recorded by the Venera-13 and -14 satellites on 1-2 February 1982. Dynamics of magnetohydrodynamic turbulence are analyzed for the  $10^{-4}$   $10^{-2}$  Hz frequency band in the area behind the leading edge of the shock wave, and absolute spectral power densities of fluctuations in the interplanetary magnetic field are computed for large scale structural areas of the shock wave. The event of 1 February 1982 is concluded to have been an example of development of a classical magnetohydrodynamic structure due to powerful flare ejection of matter. Passage of the shock wave was accompanied by a sharp increase in amplitude of fluctuations at all frequencies. The maximum spectral power was recorded in the shock layers of the forward and reverse shock waves in the area of interaction of streams of different velocities on the forward flank of the flare outburst. As the shock wave propagated through space, there was an additional increase in magnetic field fluctuation amplitudes. Figures 5; references 11: 1 Russian, 10 Western.

6508/8309  
CSO: 1866/47

UDC 550.383

INFLUENCE OF DIVERGENCE OF CORONAL HOLE MAGNETIC FIELD FORCE LINES ON  
SOLAR WIND VELOCITY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 14 May 84) pp 926-932

[Article by V.G. Yeselevich and M.A. Filippov]

[Abstract] Observations of the sun and solar wind are used to analyze the physical picture of the solar wind, based on the fact that the plasma originates primarily from areas on the surface of the sun with open magnetic field force line configurations (coronal holes), and there is a direct proportional relationship between the area of a coronal hole and the velocity of the plasma reaching the Earth from it. It is demonstrated that this velocity may change due to redistribution of the initial energy in the plasma between kinetic and thermal energies, possibly regulated by the divergence of magnetic tubes in the coronal hole above the radial divergence. A physical picture of the formation of the solar wind is developed on the basis of the results obtained. Figures 5; references 20: 4 Russian, 16 Western.

6508/8309  
CSO: 1866/47

OPTIMAL SOLAR STABILIZER PARAMETERS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 25 Mar 85) pp 933-936

[Article by A.M. Yanshin and S.M. Zabluda]

[Abstract] Previous studies have analyzed the problem of a solar rudder. Expressions for the solar pressure forces acting on a conical stabilizer in previous works have been incorrect. This article derives these expressions once more in general form and refines some of the results of the previous works. The earlier, incorrect equations indicated somewhat reduced values of natural frequency of the stabilizer and improperly determined the optimal range of aperture angles of conical stabilizers. Figure 1; references 9: 7 Russian, 2 Western.

6508/8309

CSO: 1866/47

UDC 581.521

ENERGY SPECTRA AND FLUX OF ALBEDO GAMMA QUANTA WITH ENERGY OVER 30 MeV

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 21 Mar 86) pp 936-938

[Article by V.V. Dmitrenko and V.B. Komarov]

[Abstract] The major interest in studying the albedo gamma radiation results from the fact that it can be used to determine the effective speed of gamma telescopes in orbit. This calibration in orbit requires the most precise possible knowledge of the spectra of atmospheric gamma quanta at various zenith and azimuthal angles at various latitudes. An analytic solution of the problem is analyzed in this article for energy of gamma quanta over 30 MeV in the approximation of the B cascade theory. Figures 2; references 5: 2 Russian, 3 Western.

6508/8309

CSO: 1866/47

UDC 550.388.2

HORIZONTAL COMPONENT OF ELECTRIC FIELD IN MESOSPHERE BASED ON ROCKET  
EXPERIMENT RESULTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 23 Sep 85) pp 938-941

[Article by V.I. Struminskiy]

[Abstract] Results are presented from rocket studies of the horizontal component of the quasistatic electric field at altitudes of 50 to 90 km. High values of horizontal component of field intensity, up to 5 V/m, are found for the first time. The values of the horizontal component in the mesosphere are thus found to reach several volts per meter, while the density of the horizontal conductivity flux is  $10^{-9}$ - $10^{-8}$  A/m<sup>2</sup>. Figures 2; references 8: 5 Russian, 3 Western.

6508/8309

CSO: 1866/47



UDC 550.383

ROCKET MEASUREMENTS DURING PASSAGE OF INTERNAL GRAVITY WAVES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 3 Apr 86) pp 941-943

[Article by G.L. Gdlevich, V.F. Gubskiy, V.M. Shashuikina and L.A. Yudavich]

[Abstract] A rocket was launched from the Kapustin Yar station near Volgograd on 21 December 1981 at 2137 hours local time. The rocket, a part of the "Intercosmos" program, reached an altitude of 1500 km during the time of passage of the "Intercosmos-Bulgaria 1300" satellite over the launch area. Although the flight of the rocket lasted just 23 minutes, the status of the ionosphere as measured during ascent and descent was different. Variations in intensities of auroral electrojets and the state of the atmosphere are noted. Figures 2; references 4: 3 Russian, 1 Western.

6508/8309

CSO: 1866/47

UDC 612.014

PROBLEM OF GROWTH RATE OF CRYSTALS ON EARTH AND IN WEIGHTLESSNESS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 21 Feb 85) pp 947-950

[Article by S.I. Aladev]

[Abstract] A study is made of the growth of crystals in cylindrical horizontal ampules, assuming that the gas phase in the ampules is a binary mixture of the active and inert components. Natural convection is found to decrease the average growth rate where the Ra number is small. Since the density, viscosity, temperature conductivity and diffusion coefficient of the vapor-gas medium are functions of pressure, the growth rate is also a function of pressure. The variation in crystal growth rate in a horizontal ampule as a function of natural convection intensity is found to be nonmonotonic. Slight natural convection decreases the mean growth rate, while turbulent convection increases it, indicating that there is a certain area of Ra numbers in which the flow of matter to the surface of the crystal is minimal. Figure 1; references 10: 6 Russian, 4 Western.

6508/8309

CSO: 1866/47

## SPECIFICS OF PROPAGATION OF VLF CHORUSES IN MAGNETOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 6 Jan 86) pp 996-1002

[Article by F. Irzhichek, O.A. Maltseva, E.Ye. Titova, P. Triska and  
T.A. Yakhnina, Polar Geophysics Institute, Kola Affiliate, USSR Academy of  
Sciences; Institute of Geophysics, USSR Academy of Sciences]

[Abstract] A study is made of the specifics of propagation of natural VLF chorus-type radiation based on data recorded by the "Intercosmos-19" satellite (orbital inclination  $74^\circ$ , apogee 1000 km, perigee 500 km) which recorded VLF signals in the 0.07-20 KHz band. The space and time characteristics of the signals in the upper ionosphere were recorded. It was found that the choruses were recorded in the area of the L-shells below  $L_p$ . The dimensions of the space in which magnetic activity was recorded decreased with increasing magnetic activity. The trajectories of VLF waves from their equatorial source were calculated to interpret the results obtained. It was shown that only waves originating near the plasmopause reached the satellite altitude. The great spatial scale, over 1000 km, of the VLF chorus recording zones results from arrival at various latitudes of waves with various angles with the magnetic field at the equator. Specifics of the propagation of the VLF waves also explain the space and time characteristics of the choruses. Figures 3; references 9: 3 Russian, 6 Western.

6508/8309

CSO: 1866/69

UDC 550.388.2:551.510.535

FLUCTUATIONS IN VARIOUS IONOSPHERE AND THERMOSPHERE PARAMETERS AT ALTITUDES  
IN THE LOWER PORTION OF THE F REGION IN MODERATE AND LOW LATITUDES IN JANUARY  
1974

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 17 Feb 86) pp 899-905

[Article by M.N. Fatkullin, K.U. Vagner, S.K. Annakuliyev, T.V. Gayvoronskaya, A.D. Legen'ka, A. Muradov and A.Ya. Feldshteyn, Central Institute of Astrophysics, East German Academy of Sciences; Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, USSR Academy of Sciences; Institute of Physics and Technology, Turkmen SSR Academy of Sciences; Inter-departmental Geophysics Committee]

[Abstract] Results are presented from analysis of data obtained in combined measurements performed with the AE-C satellite in January 1974. Analysis consisted of isolating fluctuations in various parameters by statistical methods as the satellite moved in an orbit with a period of 131 minutes, inclination  $68^\circ$ , perigee about 150 km located in the middle latitudes of the Northern Hemisphere, apogee about 4,200 km located in the Southern Hemisphere. Previous analyses by American authors have indicated the characteristic scales of heterogeneities, from a few tens to a few hundreds of kilometers. Coherence in fluctuations of  $n_1$ ,  $T_1$ ,  $n(N_2)$  and  $n(O)$  are noted for a broad range of characteristic scale of heterogeneities. Figure 2; references 22: 5 Russian, 17 Western.

6508/8309

CSO: 1866/69

UDC 550.388.2

APPEARANCE OF LENS PROPERTIES OF DISTURBED IONOSPHERE REGION IN STATISTICAL CHARACTERISTICS OF SLANT SOUNDINGS SIGNALS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 12 Dec 85) pp 917-922

[Article by N.V. Bakhmeteva, Yu.A. Ignatev, Yu.V. Mitikhin and V.V. Tamoykin,  
Gorkiy Radophysics Institute]

[Abstract] Results are analyzed from experiments on the reception of test waves passing through an artificial disturbed area created in the F layer over short (about 260 km), long (about 3,000 km) and very long (about 41,300 km) paths. The statistics of the signal received were found to be determined greatly by the zone in which the reception point was located with respect to the disturbed area--the near or the far zone. Differences observed in the changes in statistical characteristics of test wave amplitudes are explained by considering the mutual position of the large scale disturbed area, created by a powerful radio transmitter, and the reception point. The large-scale ionospheric lens has an averaging influence on the correlation characteristics of the signal field at the reception point. This effect is manifested as an increase during the period of heating of the time interval of correlation of signal amplitude in the far zone, with a decrease in variation coefficient and amplitude fluctuation spectrum width. Figures 3; references 13: Russian.

6508/8309

CSO: 1866/69

## ACTIVE PHASE OF SUBSTORM BASED ON SURFACE AND SATELLITE DATA

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 1 Oct 85) pp 963-969

[Article by T.V. Kozelova, Zh-P. Treyyu, A. Kort, G. Kremzer, L.L. Lazutin, A.O. Melnikov, A. Pedersen and Ya.A. Sakharov, Polar Geophysics Institute, Kola Affiliate, USSR Academy of Sciences].

[Abstract] A study is made of the appearance of the active phase of a substorm in the midnight sector based on surface data in the auroral zone and satellite measurements near the equatorial plane at  $6.6 R_E$ . The period of maximum intensity of substorm current is isolated and variations in the flows of energetic protons and electrons in the magnetosphere are studied as an intensive longitudinal current passes through the meridian of the satellite in the Western current wedge of the substorm. The surface characteristics were used to determine the moments of activation and the time when the variation in D component related to a large-scale auroral convexity strengthened. The distribution of the beginning of activation was found to be nonuniform. The maximum auroral expansion was found to reflect near continuous generation of substorm activity. Rapid dipoling of the magnetic field and reverse correlation of proton and electron flows in the magnetosphere at the satellite altitude were related with the Western edge of the expanding auroral convexity. The maximum current intensity phase featured activation events at intervals of about 5 minutes encompassing a large area of latitudes. Figure 3; references 16: 4 Russian, 12 Western.

6508/8309

CSO: 1866/69



UDC 550.388.2:550.34.062

ELECTRIC FIELDS AND HYDROMAGNETIC WAVES IN IONOSPHERE ABOVE EARTHQUAKE FOCUS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 16 Jul 86) pp 1020-1022

[Article by V.M. Chmyrev, N.V. Isayev, S.V. Bilichenko, Ye.P. Trushkina, G. Stanev and D. Gochev, Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation, USSR Academy of Sciences; Central Space Research Laboratory, Bulgarian Academy of Sciences]

[Abstract] Results are presented for the first time from an experiment studying the quasiconstant electric fields and waves at frequencies of 0.1-8 Hz over the regions of earthquakes. Measurements were performed by the "Inter-cosmos-Bolgariya 1300" satellite. It is shown that at least 15 minutes before the beginning of an earthquake, quasiconstant electric fields and hydromagnetic waves are excited in the ionosphere over the focus, significantly greater in amplitude than the background of sensitivity of present satellite hardware. Figure 1; references 7: 4 Russian, 3 Western.

6508/8309

CSO: 1866/69

UDC 523.42

PRELIMINARY ESTIMATES OF COLOR INHOMOGENEITIES AT VENUSIAN SURFACE BASED ON TELEVISION IMAGES OBTAINED BY 'VENERA-13' AND 'VENERA-14' AUTOMATIC INTERPLANETARY STATIONS

Moscow PISMA V ASTRONOMICHSKIY ZHURNAL in Russian Vol 12, No 10, Oct 86  
(manuscript received 27 Dec 85) pp 795-800

[Article by Yu.G. Shkuratov, M.A. Kreslavskiy and A.T. Bazilevskiy,  
Astronomical Observatory, Kharkov University, Kharkov; Geochemistry and  
Analytical Chemistry Institute imeni V.I. Vernadskiy, Moscow]

[Abstract] The first panoramas of the Venusian surface were obtained using television apparatus with light filters on the "Venera-13" and "Venera-14" landers. These panoramas were used in evaluating color contrasts on the Venusian surface by the cluster analysis method. Weak color differences (not greater than 10 percent) were detected for some surface sectors. The maximum color differences (0.62  $\mu\text{m}$ /0.53  $\mu\text{m}$ ) were discovered in the right part of panorama 14-1. This is an area of surface outcrops of horizontally bedded consolidated rocks not covered by loose surface material. These layers in many cases exhibit brightness differences. These rocks were probably formed as a result of eolian sedimentation of volcanic basaltic ash or other products of surface destruction of basalts. It is postulated that the color differences are attributable to differences in the degree of oxidation of matter or other factors of a chemical-mineralogical nature. However, there are other mechanisms leading to the same result, such as variations in the mean size of the grains from which the rocks consist. It has been demonstrated that with low albedos (less than 10 percent) variations in particle size can exert an appreciable influence on the color index. However, at present there is inadequate evidence for adopting one hypothesis or another. Figures 5; references 10: 5 Russian, 5 Western.

5303/8309  
CSO: 1866/29

UDC 523.42

**GEOMORPHOLOGICAL DESCRIPTION OF TESSERA FORTUNA AND TESSERA MESHKENET AREA  
(PHOTOMAP OF SURFACE OF VENUS, PLATE V-6)**

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 4, Oct 86 (manuscript received 30 Jun 86) pp 259-271

[Article by A.L. Sukhanov, Yu.S. Tyufilin, M.V. Ostrovskiy, V.A. Kotelnikov, O.N. Rzhiga, G.M. Petrov, A.I. Sidorenko, Yu.N. Aleksandrov, V.M. Dubrovin, A.I. Zakharov, G.A. Burba and V.P. Shashkina, Institute of Geochemistry and Analytical Chemistry imeni V.I. Vernadskiy, USSR Academy of Sciences; Central Scientific Research Institute of Geodesy, Aerial Photography and Cartography imeni F.N. Krasovskiy; Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] Plate V-6 was constructed from radar survey data from the Venera-15 and -16 unmanned interplanetary stations and covers the area from 60 to 80 deg north latitude and 60 to 120 deg east longitude. The entire map is on a scale of 1 : 16,000,000, and geomorphological mapping of the most complex sections is on a scale of 1 : 4,000,000. On the basis of this plate, a geomorphological description is given of areas of Tessera Fortuna, Tessera Meshkenet, the depression between them, the northern plains and the southern plain. The eastern part of Tessera Fortuna covered by the map is a parquet plateau divided into several blocks bounded by especially large troughs and ridges. These blocks moved in the northwesterly direction. The blocks of Tessera Meshkenet moved toward the south and southeast. Zones of linear displacement and coronas were completely transformed in the process in both cases. The depression between Fortuna and Meshkenet was formed by simple warping with expansion playing a minor role. At its center is a 200-km-wide volcano having radial fissures and ridges and surrounded by a horseshoe-shaped structure made up of concentric ridges. Unlike a corona, this formation is unclosed and has a volcano at its center. In the northern plains more than 400,000 square meters are occupied by lava with a large-scale network of light strips, either tectonic or volcanic. The data from plate V-6 confirm and supplement the conclusions drawn from plate V-5. The zones of linear displacement apparently represent zones of increased magma penetration. Two large subconcentric structures possibly represent the initial stages of formation of coronas. Several structural levels projecting onto the surface to various degrees can exist in the upper layers of Venus, judging from the overlapping of structures having different directions. Figures 10; references: 4 Russian.

[41-8831]

UDC 523.42

GEOMORPHOLOGICAL DESCRIPTION OF TESSERA LAIMA AND BEREGINA PLAIN AREA  
(PHOTOMAP OF VENUSIAN SURFACE, PLATE V-12)

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 4, Oct-Dec 86  
(manuscript received 30 Jun 86) pp 272-286

[Article by A.L. Sukhanov, A.A. Pronin, Yu.S. Tyufin, M.V. Ostrovskiy, V.A. Kotelnikov, O.N. Rzhiga, G.M. Petrov, A.I. Sidorenko, Yu.N. Aleksandrov, V.P. Sinilo, A.P. Krivtsov, N.N. Bobina and G.A. Burba, Institute of Geochemistry and Analytical Chemistry imeni V.I. Vernadskiy, USSR Academy of Sciences; Central Scientific Research Institute of Geodesy, Aerial Photography and Cartography imeni P.N. Krasovskiy; Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] Plate V-12 was constructed from radar survey data from the Venera-15 and -16 unmanned space vehicles and covers the area from 40 to 60 deg north latitude and 0 to 45 deg east longitude. Geomorphological mapping was performed on a scale of 1 : 4,000,000. On the basis of this plate, a geomorphological description is given of areas of Tessera Fortuna, Tessera Laima, Sigrun Furrow and Aushra Ridge, Sedna Plain and Bereginia Plain. The following formations are singled out: 1) Tesseras Fortuna and Laima, whose material exhibits a tendency toward plastic flow in the direction of mild slopes. 2) The large northeast depression which separates these tesseras and contains two large areas of extension saturated with magmatic material in the form of linear intrusions and extrusions. 3) Clusters of volcanotectonic ring systems. 4) Large annular forms (coronas) on Sedna Plain and in the area of Sigrun Furrow, which remained active even after the formation of smooth plains. 5) Frequently encountered individual volcanoes measuring from 20 to 40 and up to 100 km across; but, remarkably, very few of them in the tesseras. Various kinds of volcanic and volcanotectonic structures are seen over the entire territory which were formed by volcanism of a different type than the volcanism of basaltic plains. This raises the question of whether the products of this volcanism were also different, and, accordingly, that of the structure of the Venusian crust. The southern part of Tessera Fortuna and the northwestern part of Tessera Laima were formed from a parquet with signs of drifting down along regional slopes. The southern part of Tessera Laima is made up of an irregular or "stagnant" parquet. Large clusters of volcanotectonic systems of the center type ("spiders") were also mapped. Figures 11; references 5: 4 Russian, 1 Western.

[41-8831]

UDC 523.42

## MODELS OF THERMAL EVOLUTION OF VENUS IN PARAMETRIZED CONVECTION APPROXIMATION

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 20, No 4, Oct-Dec 86  
(manuscript received 10 Apr 86) pp 287-305

[Article by V.S. Solomatov, V.V. Leontyev and V.N. Zharkov, Institute of Geophysics imeni O.Yu. Shmidt, USSR Academy of Sciences]

[Abstract] The thermal evolution of Venus is discussed in a parametrized convection approximation. It is assumed that two-layer convection occurs, as on the earth. Four layers of the lithosphere, including the crust; the upper mantle; the lower mantle; and the core, allowing for a solid inner core, are included in the model. These four regions are joined by the imposition of boundary conditions into a complete model of thermal evolution. The thermal history of the planets is determined by the temperature reached by the time of practical completion of their growth; by the release of heat by radioactive elements and their redistribution in the course of differentiation of the planets' interiors; and by the energy of gravitational differentiation released in formation of the planets' cores. It is assumed that convection takes place independently in the upper and lower mantles of Venus, and that both convection systems interact at their boundary; the lithosphere and crust do not take part in convection but transfer heat by the usual mechanism of conduction. The convective mantle of Venus is divided into adiabatic cores (liquid and solid) and thermal boundary layers. The temperature on the surface is assumed to be constant at 733 deg K and independent of time. In the parametrized convection approximation the thickness of a boundary layer and its characteristic velocity are expressed in terms of the Rayleigh number by means of a power dependence. The models of the four main regions are discussed individually. Quasi-stationary solutions are presented for parametrized convection approximation equations, along with the results of numerical calculations. The thermal evolution of Venus is divided into three periods: 1) fine adjustment of the upper mantle to the thermal conditions of the lower mantle over approximately  $(0.5 \text{ to } 1) \times 10^8$  years; 2) transition to quasi-stationary conditions over approximately  $(1 \text{ to } 2) \times 10^8$  years; and 3) quasi-stationary conditions for approximately the last  $(1 \text{ to } 2) \times 10^8$  years. The heat flux from Venus's interior should not be greater than  $60 \text{ erg cm}^{-2} \text{ s}^{-1}$ . It is concluded that Venus has a basalt crust which is about  $70 \pm 30$  km thick. The absence of a magnetic field on Venus is associated with its thermal history. Figures 4; references 16: 3 Russian, 13 Western.

[41-8831]



FEASIBILITY OF OBSERVING SMALL ASTEROIDS WITH GALILEO, VENERA AND COMET-RENDEZVOUS-ASTEROID-FLYBY MISSIONS

Moscow ASTRONOMICHSKIY VESTNIK in Russian Vol 20, No 4, Oct-Dec 86  
(manuscript received 30 Jun 86) pp 306-318

[Article by T. Gehrels, Lunar and Planetary Research Laboratory, University of Arizona, Tucson, Arizona, USA; Physical Research Laboratory, Navrangpura, Akhmedabad, India]

[Abstract] The Soviets have discussed guiding one of the spacecraft of the Venera project to an asteroid after flyby of the planet, as was done in the case of Halley's comet in 1985-1986. Galileo and CRAF [Comet-Rendezvous-Asteroid-Flyby] flyby are being planned for known asteroids in the size range of tens or hundreds of kilometers. Flights to Vesta or a small asteroid of the type of 1627 Ivar, having a diameter of 7 km, have been discussed. In this paper the feasibility is discussed of obtaining additional fundamental data on asteroids by the observation of smaller asteroids most likely representing collisional debris. These include asteroids of about 2 km in diameter for joint study by ground and space facilities, and of about 10 m for statistical studies. The spacecraft will encounter thousands of small asteroids within reach of on-board imaging cameras. One objective is confirmation of the magnitude-frequency relation, i.e., the distribution of asteroids by stellar magnitude, and extension of this relation to meteorite sizes. Though not yet chosen, the possible instruments to be used in the CRAF project are an ISS [Imaging Science Subsystem] system having an aperture of 18.7 cm and 5 cm, and a charge-coupled-device instrument with a matrix of 1024 x 1024 elements measuring 0.018 mm each. The magnitude-frequency relation can be obtained by means of an ISS in observations of the integrated light from objects down to the size of meteorites. Auxiliary ground observations are possible for objects measuring about a few kilometers in diameter; their orbits can be determined for further study and for guidance of the ISS system. This ground support will help the missions obtain data on the composition of asteroids and comets. The first reconnaissance studies can be made by the Galileo spacecraft. The Galileo project will study the Jupiter system and the spacecraft will fly by the asteroid Amphitrite in December 1986. The Galileo project's polarimeter will make it possible to detect the regolith and surface dust with wide phase angles. Data on brightness, albedo and composition can be obtained from the combined use of polarimetry, radiometry and photometry. Figures 2; references 17: 1 Russian, 16 Western.

[41-8831]



## SURVY OF SETI RESEARCH

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 86, pp 18-28

[Article by L. M. Gindilis, candidate of physical and mathematical sciences, under the rubric "Space": "The Search for Signals from Extraterrestrial Civilizations"; source introduction printed in boldface]

[Text] A quarter of a century has gone by since the first experiments were conducted in the search for radio signals from extraterrestrial civilizations (EC)[commonly referred to in English as the Search for Extraterrestrial Intelligence or SETI]. Just what has been done over this period of time?

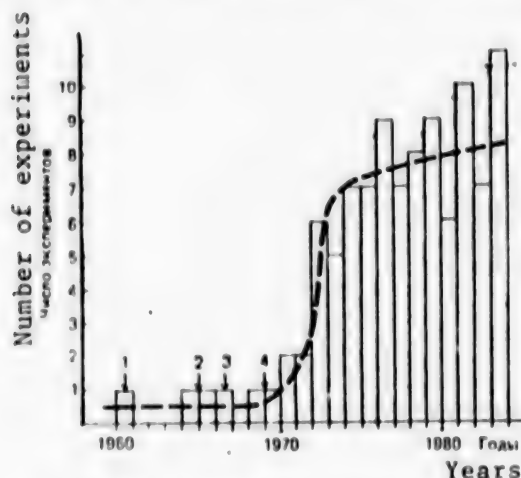
## SOME STATISTICS

The first experiment carried out by the American radioastronomer, F. Drake, in 1960 (Project Osma), embraced a search for signals in the 21 cm wavelength (the radio frequency spectral line for hydrogen) from the two sun-type stars closest to us-- $\tau$  Ceti and  $\epsilon$  Eridani. The observations were carried out on the 26 meter radiotelescope of the USA's National Radio Astronomy Observatory (NRAO). During the investigation of each star a study was made of the interval of frequencies of 400 kHz with a resolution of 100 Hz and the sensitivity amounted to  $4 \cdot 10^{-22}$  W/m<sup>2</sup>.

In 1968 and 1969 searches for signals from sun-type stars were conducted by V. S. Troitskiy. The observations were made at the radioastronomy station (NIRFI [Radio Physics Scientific Research Institute]) in Zilmenki, near Gorkiy, using the 15-meter diameter radiotelescope in the 30 cm band. A specially designed receiver with parallel sequential spectrum analysis was used, which made it possible to scan a 2 MHz-wide band with a frequency resolution of 13 Hz over a 10 minute period. the sensitivity amounted to  $2 \cdot 10^{-21}$  W/m<sup>2</sup>. The 11 closest stars and Galaxy M-31 (The Andromeda Nebula) were examined.

Originally SETI was implemented only in the USA and the USSR. But in recent years the geography of the searches has been expanded and experiments have been conducted in Canada, Australia, France, the FRG and the Netherlands. In all for the years 1960 through 1983, 45 experiments were conducted, on which

around 75,000 hours of observation time were spent (the estimation is approximate since it is not always possible to find data about the duration of the search in the publications).



1. Drake, Osma
2. Sholomitskiy, CTA-102
3. Kellerman, galaxy 1934-63
4. Troitskiy, closest stars

Distribution of the number of conducted experiments by years

During the first decade (1960-1970), four experiments were performed. After 1971, when the first Soviet-American SETI conference took place (ZEMLYA I VSELENNAYA, 1972, No 2, p 49; No 3, p 48.--Ed. Note), the SETI activity increased sharply and by the years 1974-75, seven experiments had already been carried out per year. In the future the average number of experiments in a year would amount to 7 to 8 per year.

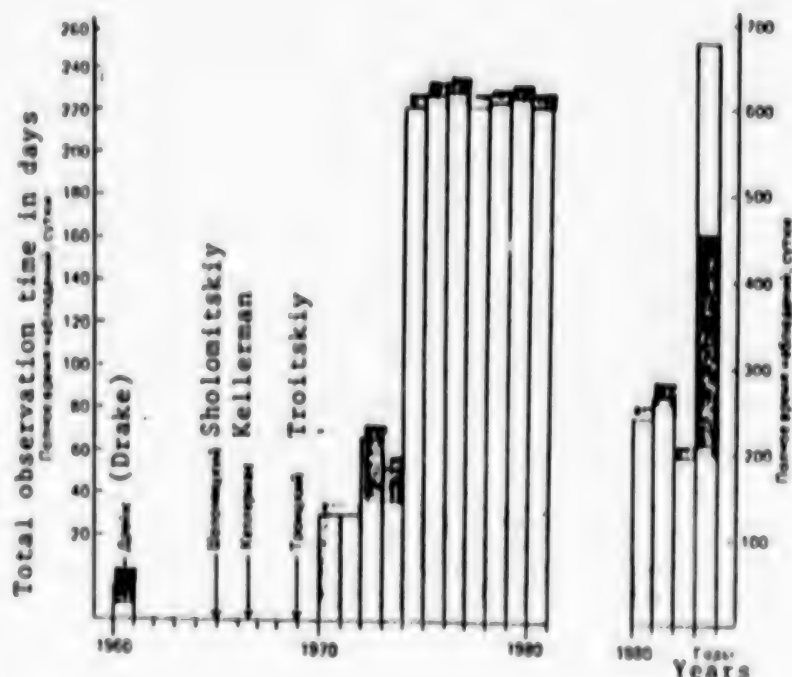
If you analyze how the full (total) observation time was distributed over the years, then you see that the biggest portion was spent on two experiments: the search for pulse signals using unipole antennas (V. S. Troitskiy et al.) and the survey of the sky in the 21 cm line, conducted at the Ohio Radio Astronomy Observatory (USA) using the (Krause) radiotelescope (R. (Dixon) et al.).

V. S. Troitskiy's experiment was conducted in the 50, 30, 16, 8 and 3 cm wavelength bands. In order to eliminate local interference, simultaneous observations were organized at several widely scattered points: in Gorkiy Oblast (Zimenki, Vasil'sursk, Pustyn), in Murmansk Oblast (Tuloma), in the Crimea (Karadag) and in the Far East (Ussuriysk). In addition, in 1972, observations were performed from on board the scientific research ship the "Akademik Kurchatov" in the equatorial waters of the Atlantic. This research led to the discovery of previously unknown sporadic radio emissions which are generated in the upper layers of the ionosphere and in the earth's magnetic field due to the influence of solar particle streams.

A search that was similar in nature, but less prolonged, was conducted in the years 1974-74 by a group of Moscow radioastronomers (the USSR Academy of Science Space Research Institute GAISH [State Astronomy Institute imeni Shternberg] and other organizations) under the leadership of N. S. Kardashev. In order to isolate the pulses of cosmic origin, it was proposed that they use the time lag of the low frequency components of the signal relative to the high frequency ones because of the radio wave dispersion during propagation in the interstellar medium. The receiving equipment included several receiving channels (from two to four) separated by frequency. Observations were made in the Caucasus, in the Pamirs and in Kamchatka.

The Ohio experiment has been going continuously since December, 1973, when it began. If you take all the stars in spectrum classes F, G and K within a radius of 100 light years from the Sun, then at any moment three or so of them will be in the "field of vision" (in the pattern) of the radiotelescope.

Distribution of the full time of observations by years. In V. S. Troitskiy's and his coworkers' experiment searching for pulse signals, in the course of the years 1970-1972, 150 days were expended, which averages out to 50 days per year. This value was used during the construction of the graph for succeeding years as well. As far as the Ohio survey is concerned, the telescope was supposed to operate on this program 24 hours a day, every day of the year. We arbitrarily adopted an effectiveness for the SETI survey equal to 50 percent; this corresponds to 4,380 hours per year. This figure was also used in the graph.



1. Amateur observations, USA: (Gray), 1983; (Couplers), 1983; (Stephens), 1983.
2. (Dixon) et al., USA, survey of sky in the 21 cm line.
3. Troitskiy et al., USSR, search for pulse signals using unipole antennas.
4. Others.

During the sending of a narrow-band signal, its frequency shifts because of the movement of the transmitter and the receiver (caused by both the rotation of the planet and the movement of the entire planetary system together with its central star). Inasmuch as the sender and the receiver know nothing about each other, their relative movement remains unknown. Consequently, the signal frequency shift is also unknown. Under the conditions of this indefiniteness, R. Dixon proposed being guided by the principle of anticryptography, according to which each of the communications partners adjusts the signal frequency to some standard common for both of them. According to Dixon, a source is adopted for such a standard, one that is fixed relative to the galaxy center. In accordance with this, the Ohio survey was conducted on the frequency of the radio spectrum line for hydrogen, adjusted to the

galaxy center. At the start they used an 8-channel receiver and later a 50-channel receiver with a 10 kHz band for each channel; the sensitivity amounted to  $1.5 \cdot 10^{-21}$  W/m<sup>2</sup>. In August, 1977, in several channels of the receiver an intensive, momentary signal was recorded, the nature of which remains unknown (the "Oho-ho" signal--see ZEMLYA I VSELENNAYA, 1980, No 5, p 37.--Ed. Note).

Data about the duration of experiments conducted using large radiotelescopes (a mirror diameter not less than that in the first experiment by F. Drake) we will list in a small table.

#### THE LARGEST RADIOTELESCOPES ARE SEARCHING FOR ETI SIGNALS

In 1964, N. S. Kardashev conditionally divided all space civilizations into three types--according to the magnitude of their power requirements. In the second group he put those civilizations whose level of power consumption equaled the radiation of sun-type stars. Then he showed that such civilizations could be discovered everywhere, not only in our galaxy but also in the nearest galaxies, even if they radiated in all directions and in a sufficiently wide band of frequencies (ZEMLYA I VSELENNAYA, 1965, No 1, p 18.--Ed. Note).

In 1975-76, American astronomers F. Drake and C. Sagan undertook the search for civilizations of the second type in the local group of galaxies, using the 300-meter radiotelescope at Arecibo. Observations were conducted on the frequencies of the 21 cm hydrogen radio spectrum line in a 3 MHz band with a spectral resolution of 1,000 Hz and a sensitivity of  $3 \cdot 10^{-25}$  W/m<sup>2</sup>. Four galaxies were investigated and 100 hours of observation time were expended.

In 1977, using the same radiotelescope, a search was conducted for radio signals in the 18 cm line from stars in our galaxy (F. Drake and M. Stull). The observations were done with a significantly higher spectral resolution (0.5 Hz) and an increased sensitivity of  $3 \cdot 10^{-26}$  W/m<sup>2</sup>.

In 1978, P. Horowitz investigated 185 sun-type stars. The search was done on the frequency of the 21 cm hydrogen radio spectrum line in a very narrow band of  $\pm 500$  Hz, centered on a laboratory standard frequency fixed relative to the center of the Sun. It was suggested that the sending civilization might be sending signals in the direction of the solar system and would adjust their frequency to the frequency of the heliocentric standard. In this operation a record spectral resolution of 0.015 Hz(!) was attained as was a record sensitivity of  $10^{-28}$  W/m<sup>2</sup>.

In this same year N. (Cohen) conducted a search at the Arecibo observatory for signals from globular clusters. The investigation was done jointly with radiotelescopes at Haystack (USA) and Parkes (Australia). At Arecibo and Parkes the search was done in the 18 cm hydroxyl line and at Haystack in the 1.35 cm water vapor line. They studied 25 globular clusters. At the same time they checked the hypothesis of T. Gold, according to which an ETI might use the effect of boosting signals with a cloud of a space maser located in



the path of the radio waves in order to create sufficiently powerful pulses along the line of sight from the other side of the maser cloud.

In 1978, W. T. Sullivan used the 300-meter radiotelescope to "eavesdrop" on ETI signals similar to our television or radio channel signals. In the course of 5 hours he observed two stars in the 3-60 cm wave band with a spectral resolution of 1 Hz and a sensitivity of  $2 \cdot 10^{-24}$  W/m<sup>2</sup>.

In 1979-81 (G. Tarter) and associates performed a search for signals from 210 sun-type stars. The observations were conducted on the frequencies of the 21 cm hydrogen and the 18 cm hydroxyl radio spectrum lines in two circular polarizations (left and right). For recording they used a digital tape recorder with subsequent processing on a computer. The system is equivalent to a analyzer having 3.4 million spectral channels and a sensitivity of  $10^{-25}$  W/m<sup>2</sup>.

#### USE OF LARGE RADIOTELESCOPES FOR ETI SIGNALS SEARCH

Size of radio-telescope	Observatory	Time of Observations <sup>1</sup>
26 m	NRAO (project Osma), USA	400 h
305 m	Arecibo, USA	100+10+80+40+5+100+75=410 h
100 m	Effelsberg, FRG	2 h
91 m	NRAO, USA	4+500+100+700=1304 h
12 25m mirrors	Westerbork, the Netherlands	400+600+4=1004 h
40 m x 240 m	Nancay, France	1+2+80=83 h
64 m	New South Wales, Australia	(?)+20+50=70 h
64 m	Goldstone, NASA, USA	400 h
64 m	Tidbinbilla, NASA, Australia	800 h
21 m x 110 m	Ohio, USA	>10 years of cont. obser.
46 m	Ontario, Canada	140+72=212 h
43 m	NRAO, USA	9+7=16 h
8 16 m mirrors	TsDKS (Deep-Space Comms. Ctr) Crimea, USSR	5 h
36 m	Haystack, USA	20 h
126 m	Kitt Peak, USA	(?)+100>100 h
26 m	Oak Ridge, USA	>1 year of cont. obser.

1. In a case where a given telescope is used for more than one experiment, the time spent on each experiment and the general, total time is indicated in the column (in the form of an equation).

Finally, in 1982, P. Horowitz conducted a search on the 300-meter radiotelescope for signals from stars on the frequency of the hydrogen radio spectrum line 1420.4 MHz (150 Stars) and on the doubled frequency 2840.8 MHz (250 stars). As in the work from 1978, a comparatively narrow band (2 kHz and 4 kHz) was precisely centered on the frequency of the heliocentric standard,

on the assumption that an adjustment of the frequency, taking into consideration the movement of the transmitter relative to the Sun, will be made by the sending civilization. The equipment, which has been given the name "Suitcase SETI," is a spectroanalyzer (in real time), which includes more than 130,000 spectral channels with a width of 0.03 Hz and a sensitivity of from  $4 \cdot 10^{-28}$  to  $6 \cdot 10^{-28}$  W/m<sup>2</sup>.

Sufficiently effective use has also been made of another large instrument--the 90-meter NRAO radiotelescope. In 1971 (H. Werscher) conducted a search with this radiotelescope for signals from the three closest stars to us:  $\tau$  Ceti,  $\epsilon$  Eridani and  $\delta$  Cygni. The observations were made in the 21 cm band; use was made of a spectroanalyzer with 192 channels with a width of 490 Hz and a sensitivity of  $5 \cdot 10^{-24}$  W/m<sup>2</sup>. In the years 1972 through 1976 P. Palmer and B. (Zukerman) investigated 674 sun-type stars in the 21 cm band. They used a 394-channel spectroanalyzer which operated on a real-time basis with a resolution of from 4 to 64 kHz and a sensitivity of  $10^{-23}$  W/m<sup>2</sup>. In 1977 D. (Black), (G. Tarter) and others used the same 90-meter radiotelescope to study 200 sun-type stars in the 18 cm band with a 5 Hz resolution. They used a high-speed tape recorder of the type used in systems for radiointerferometry with an extralong base line in combination with a direct Fourier transformation adapter. The processing was not done on a real-time basis. The sensitivity was  $10^{-23}$  W/m<sup>2</sup>.

Finally, in 1983, M. (Damasec) conducted a search for signals of the type used in our telemetry systems. He sought solitary square-wave pulses subjected to distortion because of dispersion in the interstellar medium. For this purpose he studied recordings of the sky survey made using the 90-meter NRAO telescope in the pulsar search program.

The largest fully steerable 100-m radiotelescope, located in Effelsberg, near Bonn (FRG), was also used in the search for ETI signals. In 1977 R. (Velebinsky) used it to search for pulse signals from three stars in the 21 cm band. This was done in the course of carrying out the pulsar search program. The computer was fed the coordinates of the three sun-type stars and went through the complete procedure for searching for pulse signals, entering into the search for pulsars and making it possible to record pulses with a period of from 0.3 to 1.5 seconds at a sensitivity of  $4 \cdot 10^{-23}$  W/m<sup>2</sup>.

Using the large radiotelescope in Nancay (France), three experiments were carried out and Soviet scientists participated in two of them. In one of these operations the Soviet scientists investigated the statistical characteristics of radiation from the OH maser sources. As is well known, the natural sources of radio emission are noisy by nature and therefore the statistical properties of the radiation correspond to the statistical properties of noise. For example, the amplitude distribution satisfies Gauss' law. For artificial signals the distribution, generally speaking, differs from the gaussian. M. (Holly) proposed using a similar circumstance for isolating artificial sources. Subsequently this matter was analyzed by V. I. Slysh, L. I. Gudzenko, B. N. Panovkin and V. I. Siforov. After the discovery of the OH maser sources, N. S. Kardashev proposed studying their statistical structure. Under his supervision, G. M. Rudnitskiy (GAISH) developed a



special adapter for radiometry in the 18 cm line, making it possible to carry out such an analysis. The observations were made by Ye. Ye. Lekht, M. I. Pashchenko, G. M. Rudnitskiy and V. I. Slysh in 1971 and 1972. A study was made of the statistical structure of the radiation from sources OH, W3, NGC 6334 A, Sgr B2 and W49. None of them showed any notable deviation from the gaussian distribution.

The second operation was performed by that same collective in 1972 on the initiative of V. I. Slysh. In the intervals between observations for the basic program a search was conducted for signals from the 10 stars closest to the Sun on the frequency of the 18 cm hydroxyl radio spectrum line.

In 1981, (F. Bireau) and (G. Tarter) used the large radiotelescope in Nancay to study 300 sun-type stars. The observations were made in the OH lines on frequencies 1665 and 1667 MHz (the main lines) and 1612 and 1720 MHz (the satellite lines), and also on the frequencies inbetween and (weighted from) the frequencies of the main lines. Use was made of 1,024-channel, autocorrelating spectrometer operating on a real-time basis. The resolution was 100 Hz with a sensitivity of  $10^{-23}$  W/m<sup>2</sup>. This work was a continuation of searches previously conducted at the USA's NRAO and at Arecibo within the framework of the general program for the discovery of narrow-band signals from sun-type stars.

P. V. Makovetskly's hypothesis about the synchronization of galactic communications according to the flashes of supernovas and novas was tested using the RATAN-600 radiotelescope. If an ETI emits a signal in the direction of the solar system at the moment it observes a flash from a certain star, then, knowing the distance from this star to the ETI and to the Sun, as well as the distance between the ETI and the Sun, it is possible to calculate the moment of the signal's arrival relative to the moment the flash of that same star is observed on Earth. Proceeding from this hypothesis and using the flash of (Nova) Cygni from 1975 as the "sync signal," P. V. Makovetskly calculated the theoretical moments of communications for several of the closest stars. In September of 1978, on the calculated dates, searches were undertaken on the RATAN-600 for signals from Barnard's (flying) Star, however the attempt was unsuccessful.

#### SETI IN THE OPTICAL BAND

For the search for signals in the optical band, both the medium and large telescopes were used, including the 6-meter telescope of the USSR Academy of Sciences' Special Astrophysical Observatory [SAO] in the Northern Caucasus. One experiment was conducted on the Copernicus international satellite. Data about the conducted experiments we will list in yet another table. These data include both the searches for artificial objects (probes and (Dyson) spheres) and the search for optical signals.

The basic merits of an optical channel in comparison with a radio channel are: a high through-put capacity making it possible to transmit a large volume of data and ease in implementing narrow-beam transmission. Less power is required during a narrow-beam transmission, however, it is more difficult to

implement a directional search.. Therefore, it is possible to think that the ETI call signs are being broadcast in the radio band, but that the optical band or even the x-ray band of the spectrum would be used for data transmissions (after the civilizations have discovered one another). It has been proposed that signals in the optical band should be transmitted using lasers. Laser radiation would yield a narrow line in the spectrum of the star next to which the transmitting ETI is located. Therefore, the task comes down to a search for "laser stars," i.e., stars having extremely narrow emission lines.

#### SETI IN THE OPTICAL BAND

Year	Author	Observatory	Telescope diameter in meters	Spectrum field	Nature of the experiment
1973-1976	Shvartsman et al	SAO USSR AS	0.6	5500 Å	search for laser stars
1974	Vishnia	Copernicus satellite	1.0	1000 Å	search for ultra-violet lasers
1978-1979	Shvartsman et al	SAO USSR AS	6.0	5500 Å	search for laser stars
1979	(Freitas) and Valdez	University of California, USA	0.76	5500 Å	search for probes in stable orbits near libration points L4 and L5 in the Earth-Moon system
1980	Witteborn	Mount Lemon, USA	1.5	1 $\mu$ m-8 $\mu$ m; 13.5 $\mu$ m	search for infrared excesses from (Dyson) spheres near sun-type stars
1981-1982	Valdez and (Freitas)	Kitt Peak, USA	0.61	5500 Å	search for artificial objects at libration points L1-L5 in the Earth-Moon system and L1 and L2 in the Earth-Sun system

The search program for such stars is being implemented under the supervision of V. F. Shvartsman in the USSR Academy of Sciences' SAO. Use is being made of a specially developed set of equipment called Maniya, which makes it possible to detect ultra-highspeed (from  $10^{-7}$  to  $10^2$  seconds) time variations of a light stream, and also the ultra-narrow (less than  $10^{-6}$  Å) emission lines. The equipment is intended for searching for black holes, neutron stars and laser stars. The observations were begun in 1973 and originally (1973-1977) made on the Zeiss-600 0.6-meter telescope. From 1978 on they have been made on the 6-meter telescope. The output signal of the photometer after transformation is recorded on magnetic tape and the processing is done by computer. The primary attention in SETI has been paid to so-called ROCOS's, i.e., to radio objects with a continuous (uninterrupted) optical spectrum. Typical for them are time-variable radio and optical emissions, as well as a complete lack of the usual spectral lines.

#### CLASSIFICATION OF THE EXPERIMENTS

At the present time SETI can be divided into the following trends:

1. The search for narrow-band signals from specific astronomical objects. It is basically done on the frequencies for the 21 cm hydrogen, the 18 cm hydroxyl and the 1.35 cm water vapor radio spectrum lines. For this, use is made of the largest radiotelescopes and highly precise, highly sensitive, multi-channel receiving equipment containing tens, hundreds, thousands and right on up to a million spectral channels and making it possible to conduct real-time spectrum analysis. In individual experiments a resolution capacity of several herz and even a portion of a herz was attained. Primary attention has been paid to sun-type stars and in several instances to other objects (nearby galaxies and globular clusters).

2. The search for pulse signals of unknown origin. Here use has been made of both sky surveys using large radiotelescopes (done for the purpose of searching for pulsars) and observations with omnidirectional antennas taking in the whole celestial dome. The latter experiments have relatively low sensitivity and are intended for the discovery of only very strong signals.

3. The investigation of several peculiar objects: the galactic center, the search for the variability of CTA-102, the study of the statistical structure of radio sources and the search for laser lines in the spectrum of ROCOS's.

In a class by itself is the radio survey in the 21 cm line performed at the Ohio University Observatory

Another principle serves as the basis for a classification system proposed by (G. Tarter). It divided all the experiments into three groups: the direct immediate SETI using specific objects (as a rule, here the usual radioastronomy equipment is used); the concomitant experiments when the SETI is conducted coincidentally with the carrying out of a basic (astrophysical or applied) program; and research specially intended for SETI, not only concentrated on the tasks of the search but also using in it equipment specially developed for these purposes.

The first observations by F. Drake (project Osma) and the majority of experiments carried out up to the middle of the '70's are related to the first group. An example of the concomitant experiments would be the search for ETI pulse signals in the process (or according to the data) of radio surveys carried out for the purpose of discovering pulsars. Another example would be the study of detailed maps of the sky, which have been obtained as a result of the 21 cm line survey on the Westerbork radio telescope (the Netherlands), for the purpose of searching for localized emission sources which coincide with the position of the stars. In an instance of coincidence it is possible to suggest that we are dealing with an artificial source (a generator) located near the star and operating on the hydrogen radio spectrum line frequency. Such research has been performed by (F. Israel) and (de Ruyster) in 1975-1977 and they studied the coincidence of point emission sources with stars from the AGK-2 catalog. In 1981 (F. Israel) and (G. Tarter) continued this work: they studied the coincidence with stars from the AGK-3. The work of V. F. Shvartsman in connection with the search for laser stars also belongs to the category of concomitant experiments.

A group of researchers from the University of California in Berkeley and the Jet Propulsion Laboratory (USA) designed a special device (SERENDIP) intended for concomitant SETI's. It is a relatively simple automated 100-channel spectrum analyzer which operates on a parallel basis with the basic equipment, investigating the intermediate band of frequencies. At the same time, a search is implemented and a recording is made on magnetic tape of any strong signals observed only in the one 2.5 kHz spectral channel. Such a set-up has been used at the Hot Creek Observatory during observations using the 26-meter radiotelescope in the 6, 18 and 21 cm waves. The telescope itself operated according to the astronomical program. Since 1979 a similar device (SERENDIP-2) has been used on the 64-meter NASA radiotelescope at Goldstone. The search is being implemented in directions which have been determined by the position of NASA's space objects in the celestial sphere. At the present time a new modification of the SERENDIP system has been developed and a proposal has been made to install it on the 300-meter radiotelescope in Arecibo.

A curious example of concomitant observations has been demonstrated by (S. Gulkis) and his colleagues on the other 64-meter NASA radiotelescope in Australia. The scientists managed to convince NASA's management to let the radio telescope equipment continue operating during repairs to the mechanical part of the antenna. They set up a 256-channel spectrum analyzer and used it to conduct observations on the 8 and 22 GHz frequencies of the part of the sky where the antenna was aimed. When the repair schedule permitted, the antenna's elevation was changed and thus a partial survey of the sky was conducted.

An example of an experiment specially designated for SETI is the Ohio survey in the 21 cm line. Another example is the SENTINEL project being carried out at the Oak Ridge Observatory in the USA (P. Horowitz et al.). The project envisages the conducting of an automated survey of the sky using the 26-meter radiotelescope on several "magic" frequencies: 1420.4 MHz (the hydrogen radio



spectrum line), 2840.8 MHz (the doubled hydrogen frequency) and the hydroxyl radio spectrum lines--1667.3 and 1665.4 MHz. Use was made of the Sultcase SETI equipment developed by P. Horowitz, with a resolution in the hydrogen line of 0.03 Hz and in the hydroxyl lines of 2 Hz and a sensitivity of  $8 \cdot 10^{-28}$  W/m<sup>2</sup>. The survey is being conducted in a circular polarization. It is also possible to relate to this the pulse signals search using omnidirectional antennas being conducted in the Soviet Union. These operations, apparently, encompass the experiments of a given category that are being conducted by professionals, but they do not encompass all experiments if you consider the contribution of amateurs.

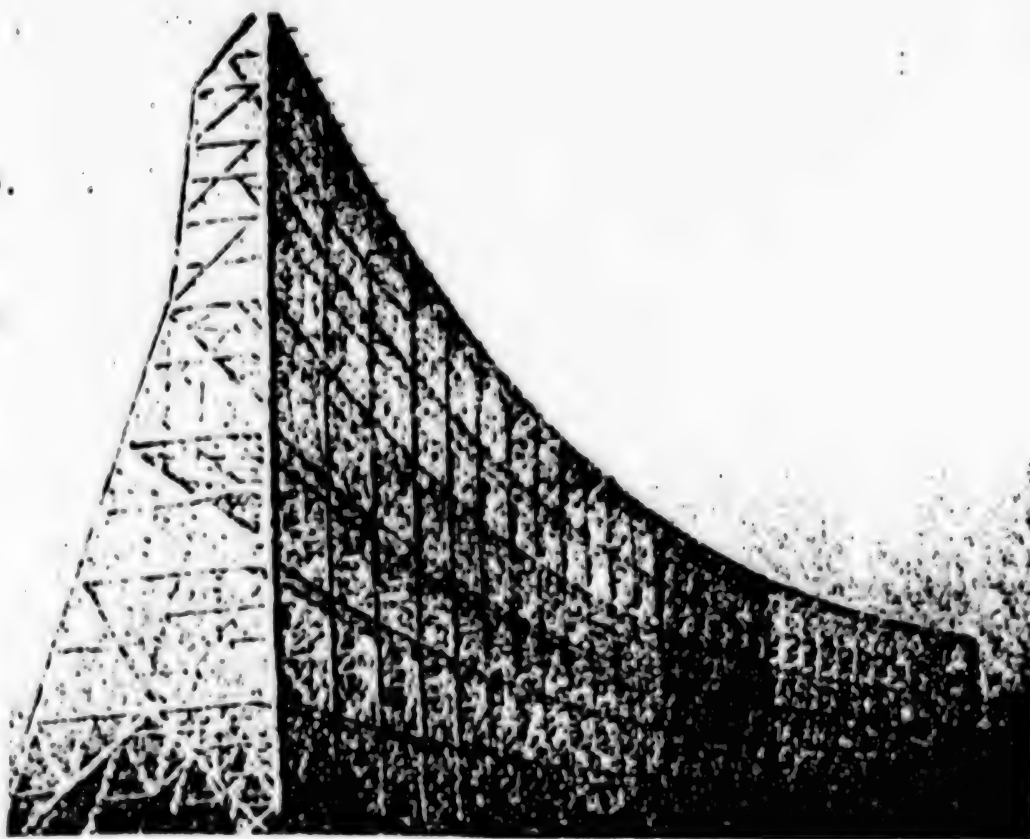
#### RADIO AMATEURS JOIN IN THE SEARCH

In 1983, the American engineer, R. Grey, and several associates built in a yard outside Chicago a "Miniature SETI Observatory." It was equipped with a 4-meter radiotelescope and a 21 cm wave receiver. The receiver operates in the 1419.5-1420.5 MHz band and has 256 channels with a spectral resolution (the band of each channel) of 40 Hz and a sensitivity of  $10^{-22}$  W/m<sup>2</sup>, i.e., one on the same order as in F. Drake's first experiments. The recording of signals is being done on magnetic disks. The entire system is controlled by a home microcomputer. The observations are being conducted daily in the evening hours. The Miniature SETI Observatory is conducting a survey of the sky on the 21 cm wave. In addition, a significant portion of the time has been spent on a study of that part of the sky where in August of 1977 the radioastronomers of the Ohio observatory discovered the previously mentioned signal of unknown nature.

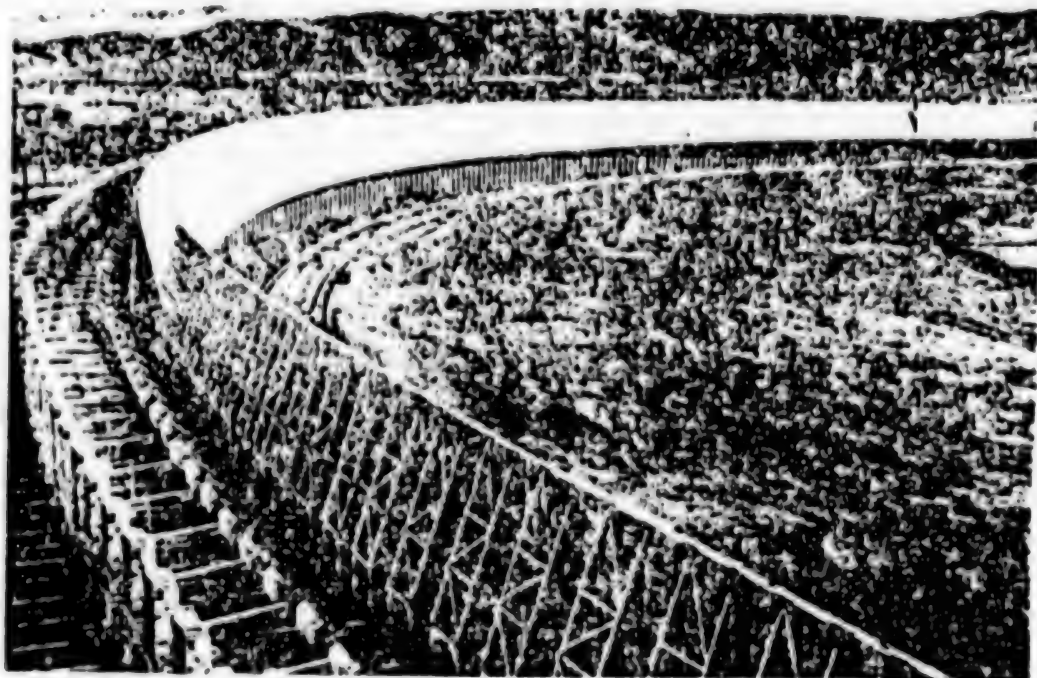
Yet another amateur SETI observatory was established by B. (Steffens) in a remote corner of Canada near the Yukon River. It was equipped with two standard 15-meter antennas used for the study of tropospheric diffusion and a receiver operating in the "water hole" region--18-21 cm. The observatory is operating according to a sky survey program.

A radioamateurs group from Silicon Valley (USA) developed a system for SETI in the 1420 Mhz wave using satellite television antennas, as well as a noiseless amplifier with gallium arsenide field-effect transistors. Yet another research trend is associated with the signals search in the frequency band below 1000 Mhz. This range lies in the microwave spectral window of the earth's atmosphere and noises here are still not too great. However, the use of large antennas in this band encounters a number of technical difficulties. Radio amateurs working in the given frequencies with small antennas can ensure acceptable sensitivity by means of averaging during repeated observations. In addition, amateurs are free of the restrictions associated at times with the use of large radiotelescopes. Therefore, you can not exclude the fact that they will be able to make a significant contribution to the solution of this important and fascinating task-- the search for signals from other worlds.

Main Mirror  
 of Large  
 Radiotele-  
 scope at  
 Nancay (France).  
 The Radio-  
 telescope  
 consists of  
 two reflectors  
 and the size  
 of the main  
 mirror is 300  
 by 35 meters



Soviet  
 RATAN-600  
 Radiotele-  
 scope  
 (part of  
 the circular  
 reflector)





## SOME RESULTS

In summation, one must, first of all, note the considerable scope of research in the field of SETI and its constant expansion. Of course, from the point of view of the complete scope of the search area, very little has yet been done. Let us remember that what is called the search area is that conditional area in which unknown search parameters are adopted for the coordinates: direction, time, signal frequency, power, polarization and so on. According to the estimate of (G. Tarter), by 1981 an area amounting to  $10^{-17}$  of the entire search area had been investigated (ZEMLYA I VSELENNAYA, 1982, No 3, p 49--Ed. Note). Consequently, the question: why have we not discovered any ETI signals up to this time?--as before, remains unanswerable. However, taking into account the lack of guarantees in obtaining a positive result, the scope of the research in the field of SETI is impressive. Particularly impressive is the use of the largest radio and optical telescopes. The astronomers know what stiff competition exists between the research programs and how difficult it is to obtain observation time on the big telescopes. Under these conditions, the readiness of the specialists to grant a considerable amount of time on the largest instruments to SETI tasking is proof of the recognition of the scientific importance of the given problem.

Attention has also been turned to the tendency already intensified in recent years to combine astrophysical tasking with Seti tasking (concomitant observations) using both the standard equipment and that specially developed for SETI. And finally, particular note must be taken of the organization of special SETI observations (special search tasking) being accomplished by means of the equipment developed for the given purposes. Also heartening is the inclusion of radio amateurs in the observations. At the same time, there remains much in the organization of the search problem that is still not clear. This is why it is necessary, along with the signals search, to continue and intensify the research on the theoretical and philosophical bases of the problem. Only the combining of experimental work with profound theoretical research, in the course of which the search program will be adjusted and improved, can lead us to success.

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CSO: 1866/42

WEAKENING IN SOLAR RAY DOSE BY GEOMAGNETIC FIELD

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 20 Sep 84) pp 944-947

[Article by M.V. Zil, A.V. Kolomenskiy and V.M. Petrov]

[Abstract] In estimating the radiation danger represented by solar cosmic rays to manned spacecraft in orbit, one must consider the shielding effect of the geomagnetic field. A method is suggested for computing this effect based on calculation of the variation in solar cosmic ray dose at a fixed point in orbit as a function of the geomagnetic threshold, which determines the minimum value of energy of particles capable of reaching the point in question from interplanetary space. The effect is computed based on the terrestrial magnetic field dose reduction factor, which defines the ratio of the dose over a certain period of time in near earth orbit to the dose outside the magnetosphere over the same period of time. The calculations demonstrate that the magnetic field of the Earth effectively decreases the radiation danger of cosmic rays for spacecraft flying at altitudes of 300-400 km. Variations in dose as a function of longitude are ignored. Figures 2; references 7: 4 Russian, 3 Western.

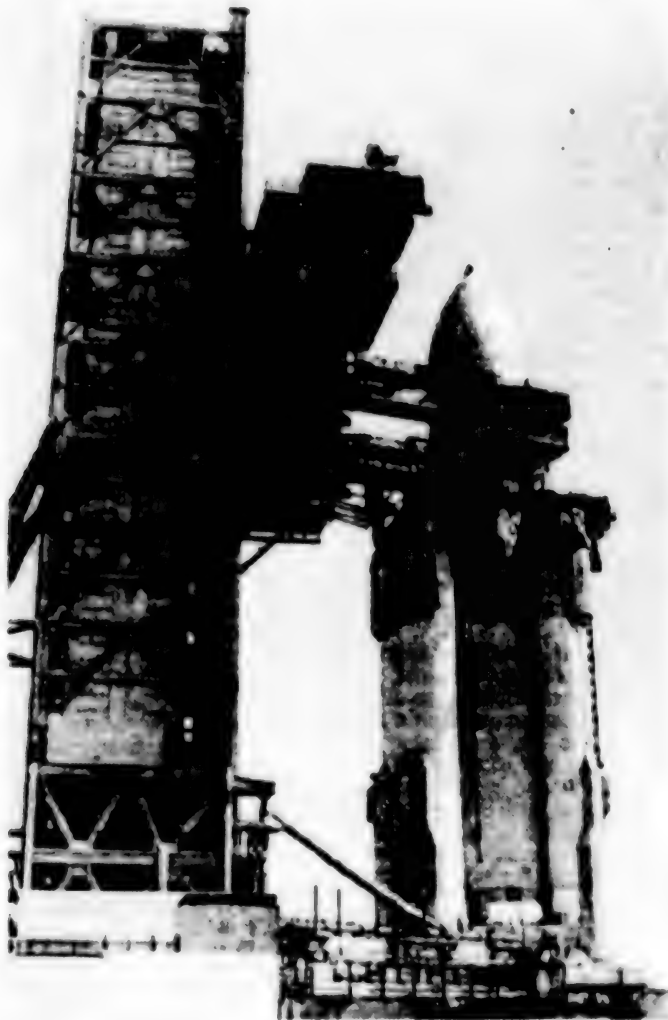
6508/8309  
CSO: 1866/47

PHOTO OF 'ENERGIYA' HEAVY BOOSTER ON LAUNCH PAD

Moscow IZVESTIYA in Russian 20 May 87 p 2

[TASS photo caption]

[Text] Flight-design tests of the new and powerful multipurpose booster rocket "Energiya" [energy] have begun in the Soviet Union. The rocket is intended for inserting into near-Earth orbits both multiple-use orbital ships and large-dimensional space apparatus for scientific and national economic purposes. The two-stage multipurpose booster rocket has a launch mass of over 2,000 tons and is capable of inserting into orbit more than 100 tons of payload. The first launch of this booster rocket took place from the Baykonur Cosmodrome.



Booster rocket "Energiya" before the launch

CSO: 1866/95-P

## ITERATION SYNTHESIS METHOD FOR IDENTIFICATION OF AERODYNAMIC CHARACTERISTICS OF SPACECRAFT FROM MEASUREMENTS OF ITS MOTION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24, No 5, Sep-Oct 86  
(manuscript received 30 Jul 84) pp 680-694

[Article by A.V. Kostrov and V.V. Gukov]

[Abstract] The identification of the aerodynamic characteristics of a spacecraft by measurements of their movements on the ballistic segments of the spacecraft flight trajectory is a fundamental problem in ballistics, but it is virtually impossible to make such direct measurements of such aerodynamic characteristics. The authors have therefore developed a method for solving the identification problem on the basis of a combination of the successive approximations method and the analytical continuation method (see A.V. Kostrov, DVIZHENIYE ASIMMETRICHNYKH BALLISTICHESKIKH APPARATOV, Moscow, Mashinostroyeniye, 1984). The prototype for the proposed synthesis method is the parametric method proposed by S.N. Bernshteyn for solving boundary value problems with nonlinear equations in partial derivatives. A solution of the problem of nonlinear identification of aerodynamic coefficients and initial conditions of spacecraft motion on the basis of measurements of its spatial motion was found after developing algorithms for the synthesis method and a mathematical model of spatial movement. A specific example of such identification is presented, together with an analysis of convergence of the identification procedure. The results of solution of the problem by the Gauss-Newton method and by the synthesis method are compared. It was found that application of the synthesis method makes it possible to solve the problem when there are greater errors in stipulation of a priori approximations of the parameters to be identified in comparison with the admissible errors when solving the problem using the successive approximations method alone. Figures 4; references 11: 7 Russian, 4 Western.

5303/8309  
CSO: 1866/32

UDC 629.19

## OPTIMIZING PARAMETERS OF SPACECRAFT POWER-ENGINE SYSTEM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 5, Sep-Oct 86  
(manuscript received 23 Apr 85) pp 695-701

[Article by M.A. Kuzmin]

[Abstract] The optimization of spacecraft engine parameters is discussed extensively in the literature, but this article gives a detailed description of the method used and a validation of the results obtained in solution of the special problem of choice of the optimal escape velocity for an unregulated engine of limited power with allowance for the mass of tanks for the working medium and under the condition that engine efficiency is  $\eta = \text{const} \neq 1$ . Since this is not an essentially new problem, the main objective of the study is a representation of the results in a new and graphic form. The component parts involved in the system analysis are the jet engine, power source and working medium storage system. By means of solution of the dynamic part of the optimization problem the functional requirements imposed on the engine can be formalized by stipulating the required increments of the characteristic velocity of the spacecraft and the duration of engine operation. Allowance is also made for the losses involved in the transformation of energy of the primary source into the kinetic energy of the working medium. The range of values of the parameters for which a dynamic maneuver can be performed is determined. A study was made of the influence of maneuver parameters and the characteristics of design sophistication of system elements on the optimal escape velocity and the optimal mass fraction of the power plant. The proposed method for determining optimal engine parameters is illustrated for an engine for performing maneuvers with stipulated parameters. Figures 4; references: 3 Russian.

5303/8309  
CSO: 1866/32

UDC 528.77:550.814+629.78:551.25

PROCEDURES FOR GEOLOGICAL INTERPRETATION OF PLATFORM AREA LINEAMENTS  
(AS EXEMPLIFIED BY THE USTYURT)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 1 Nov 85) pp 26-36

[Article by M.I. Burleshin, "Gidropetsgeologiya" Geological Production Association]

[Abstract] The geodynamic and landscape methods for the identification and interpretation of lineaments are discussed as applicable to such platform areas as the Ustyurt. Two tables give an information-yield comparison of the two methods. The first method is based on an analysis of lineaments as they are manifested in terrain geometry, whereas the second is based on lineament patterns. In the geodynamic method, in the disjunctive tectonic structure it is possible to discriminate more ancient elements reflecting the pattern of rock fissuring on both sides of a disjunctive dislocation and younger elements manifested in the intensity of fissuring in the fault itself. Differences in the pattern of lineaments make it possible to define blocks of different orders often formed by rocks of different mineralogical composition or different degrees of dislocation and a description of lineament zones based on the criterion of their characteristic direction of fissuring can be used in determining the directions of movement of blocks along lineament zones. The landscape analysis method yields much geological information on the most recent structural elements. Comparison of landscapes on different sides of a lineament makes possible a determination of the intensity and direction of the most recent tectonic movements. Study of the landscape manifestations of the lineament can yield important information useful in hydrogeological and engineering geology work. Conclusions can be drawn concerning the closeness of ground water to the surface. Figures 3; references: 15 Russian.

5303/8309  
CSO: 1866/25



UDC 528.88:553.042

PRINCIPLES AND METHOD FOR SIMULATING ORE BODIES IN PREDICTIVE METALLOGENETIC RESEARCH (USING SPACE INFORMATION)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 24 Sep 85) pp 37-43

[Article by M.A. Beloborodov and V.S. Kogen, "Aerogeologiya" Geological Production Association, Moscow]

[Abstract] Models of ore bodies are necessary for representation of the most common properties of ore bodies associated with ore formation processes under specific geological conditions and for clarifying specific features which could serve as indicators of ore bodies, different types of mineralization or ore formations. Due to this dual purpose of such modeling, it is deemed necessary to develop models of two classes: 1) for characterizing the specific distinguishing features of ore bodies intended for study of the geological position of mineralization in a region and reflecting the most typical conditions of its localization, but also for comparative purposes in prediction work, a so-called "standard" model providing an orderly description of the most typical properties included in the model regardless of their occurrence beyond the limits of ore bodies, 2) a so-called "optical" model, an orderly description of distinguishing properties selected from among the criteria for the entire studied area and with allowance for their occurrence beyond the limits of known ore bodies of the predicted type. Application of these principles is illustrated applicable to molybdenite-quartz mineralization in the Far East. These two classes of models of ore bodies correspond to the purposes of predictive metallogenetic research: study of general geological conditions for the localization of mineralization and detection of new, promising ore bodies. Information obtained in the processing of space photographs is highly important for both classes of models, making possible more detailed mapping of mineral deposits and the revelation of new, earlier unknown ore-controlling factors. Figure 1; references: 6 Russian.

5303/8309  
CSO: 1866/25

UDC 528.72:551.23

QUANTITATIVE PROCESSING METHODS AND INFORMATION YIELD OF SPACE PHOTOGRAPHS  
IN PREDICTING STRUCTURAL INHOMOGENEITIES OF SEDIMENTARY COVER

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 20 May 85) pp 44-54

[Article by V.Ya. Vorobyev and V.A. Bashmakov, Lower Volga Scientific Research  
Institute of Geology and Geophysics, Saratov]

[Abstract] Procedures are proposed for the processing of space photographs for use in space geology, exemplified in the prediction of structural inhomogeneities of the sedimentary cover in the area of the Caspian depression and its marginal sectors. A series of maps was constructed representing the distribution of optical density of space photographs, density of lineaments and anomalies of geophysical, structural and geomorphological indices. This, in combination with other observational and archival data, made it possible to define the factors exerting the strongest influence on the distribution of optical density. There is a very strong relationship to depth of the basement, amplitude of recent tectonic movements, local relief and surface dissection, anomalies of the gravity and magnetic fields. Uplifted blocks correspond to an increase in the density of lineaments, a decrease in the optical density on space photographs and an increase in its gradient. In addition, the optical density is dependent on the distribution of the amplitudes of neotectonic movements and parameters characterizing the distribution of geophysical, structural and geomorphological indices. The optical density of space photographs, for example, increases with a decrease in the vertical dissection of relief and with an increase in residual magnetic field anomalies. In addition to optical density and residual anomalies, in predicting structural inhomogeneities of the sedimentary cover the density of lineaments on photographs is highly important. Such information is valuable in evaluations of the possibilities for presence of petroleum and gas, as in the Caspian depression. Figures 5; references: 19 Russian.

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UDC 528.7:681.3

## DEVELOPMENT OF METHOD FOR INTERPRETING FORESTS ON TEXTURE-SELECTIVE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 18 Dec 85) pp 55-66

[Article by V.I. Kravtsova, Geography Faculty, Moscow State University imeni M.V. Komonosov, Moscow]

[Abstract] A set of keys (fragments of images of forests with known composition, structure, quality and other parameters) was prepared in order to define interpretation criteria for forests of different types on texture-selective photographs. The systematized sets of keys was prepared in the form of a single photograph consisting of 24 square fragments of aerial photographs at an original scale of 1:56,000 taken with an MKF-6 camera in the green spectral zone, enlarged to 1:18,000. The forest cover was uniform within each key sector. The fragments were taken from the central and marginal parts of the photographs in order to check the influence of position in the photograph field on the structurally transformed image. The entire mosaic of fragments was checked twice, with their different orientation, simulating a survey from different solar altitudes, in order to check the influence of this factor. Two different variants for joining the fragments were used. The characteristics of the forest represented on these fragments were determined from aerovisual observations, as well as an analysis of the image based on very greatly enlarged (50<sup>x</sup>) aerial photographs. Use was made of texture-selective photographs taken in different spectral zones: 1.45, 2.3, 4.25, 6.2, 8.6, 12.8, 16.1 and 33.2 nm<sup>-1</sup>. A comparison revealed differences in the spectra of spatial frequencies of images of different types of forest vegetation. A set of 96 frequency-spectral images was obtained for all the key fragments. Their analysis made it possible to define five groups of formations with similar frequency-spectral image curves and to ascertain their generalized characteristics, these serving as the basis for interpretation criteria. Each of these groups is discussed and different interpretation stages are outlined. The results are illustrated in a specific example. A comparison of these results with an interpretation based on a highly enlarged multizonal space photograph of the same region revealed that texture-selective photographs yield much additional information. Figures 7; references: 4 Russian.

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CSO: 1866/25

UDC 528.8.042.3:631.44

## DETERMINING PROPERTIES OF CULTIVATED SOIL HORIZON FROM MULTIZONAL SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 1 Aug 85) pp 67-77

[Article by L.N. Vasilyev and V.M. Mazikov, Geography Institute, USSR Academy of Sciences, Moscow]

[Abstract] Procedures are proposed for determining the properties of soils from multizonal space photographs on the basis of clustering of the brightnesses of the plowed soil horizons and a multivariate statistical analysis. The method was tested in a territory with an area of 27,000 km<sup>2</sup> occupied by a number of soils, such as dark chestnut and chernozem. The study was based on photographs obtained using the "Fragment" space multispectral scanning system operating in the range 0.8-1.1  $\mu$ m carried aboard a "Meteor" satellite. The minimum brightness corresponded to cultivated surfaces without vegetation, fallow or sown with winter crops. The brightness of the plowed horizons was measured in four channels in both spring and autumn. The measurement unit was an agricultural field with an average area 100-250 hectares. The multiple linear regression analysis indices obtained for different soil zones varied as a function of the relationship of components (of which humus and carbonates are the most important) and their dispersions. The method makes it possible to determine the correlation between the content of organic matter and the chemical composition of mineral compounds and their spectral brightness and to ascertain the most significant of these. The method therefore makes it possible to judge the direction of soil formation processes either in the direction of leaching, which may be associated with prolonged moist periods, or in the direction of an increase in the concentration of carbonates as a result of drought. A comparison of such observations with data from past years affords a possibility for objective evaluation of the degree of degradation of intensively cultivated chernozems. Figures 5; references: 4 Russian.

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UDC 681.3+528.72

USE OF MULTIDIMENSIONAL HISTOGRAM FOR COMPUTING MAIN COMPONENTS OF MULTIZONAL IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 12 Jul 85) pp 90-94

[Article by G.A. Alferov, All-Union Scientific Research Center "AIUS-agroresursy," Moscow]

[Abstract] The discrimination of main components is widely used in processing remote sensing data. The procedures for this involve great difficulties due to the large volume of data and complicated computations, especially with respect to the required covariation matrix. Three successive steps have been used in calculating the main components. Various procedures have been proposed for accelerating computations of the main components, but all of these have deficiencies. A new method is proposed for this purpose. It is based on the construction of multidimensional histograms such as already in wide use in programs for cluster analysis of multizonal images (see S.W. Wharton, PATTERN RECOGNITION, Vol 16, No 2, pp 193-199, 1983). Specific formulas and algorithms for the necessary procedures are given. The program for computing the main components in FORTRAN-4 using a minicomputer is outlined. The proposed procedures accelerate computations in the first two steps in computing the main components by a reduction in the number of arithmetical operations and elimination of need for an element-by-element scrutiny of the initial image. If the computer main memory is too small to hold the multidimensional histogram with the initial number of quantization levels it is possible to use a truncated version which results in only a small accuracy loss. If truncation is used, it is essential to employ a maximum dynamic range of initial data. References 7: 4 Russian, 3 Western.

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CSO: 1866/25



"DC 629.7:631.1

**AUTOMATION OF THEMATIC PROCESSING OF SPACE IMAGES IN EVALUATING STATE OF AGRICULTURAL CROPS**

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 6 Sep 85) pp 95-102

[Article by G.G. Andreyev, V.P. Bocharov, N.V. Sazonov and L.N. Chaban,  
All-Union Scientific Research Center "AIUS-agroresursy," Moscow]

[Abstract] Use of multizonal aerospace information makes it possible to evaluate the state of agricultural crops and determine the areas which they occupy. This can be accomplished using a flexible interactive system for automated thematic interpretation. A variant of such a system was developed for processing high- and medium-resolution multizonal space scanner images. The thematic processing scheme involves five main stages: statistical analysis of a priori data ensuring the choice of keys (standards) and optimal survey times; accumulation and analysis of interpretation criteria for the studied classes of agricultural crops in key sectors; discrimination of the boundaries of uniform regions on images (segmentation); automated image classification in a dialogue regime; identification. The first and last of these processing stages are accomplished for the most part in an interactive mode with the participation of experts and interpreters. In the first stage a mass of data is formed and analyzed, taking into account agroclimatic conditions, phenological development of crops and distribution of sown areas. Thematic analysis begins in the second stage, in an interactive regime with participation of an interpreter. In the process of analysis use is also made of data from surface and aerovisual studies of key sectors. Brightness and texture are analyzed. An evaluation is made of the information content of each spectral range. Boundaries are defined using nonparametric statistical segmentation algorithms. The procedures are illustrated in the example of an area in Stavropol Kray using space images obtained by the "Fragment" system (early June). The described segmentation and classification procedures provided a satisfactory evaluation of the state of agricultural crops (good, satisfactory, unsatisfactory). Figures 3; references: 10 Russian.

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UDC 629.19:551

METHOD FOR COMPUTING SCANNING FREQUENCY FOR SYSTEM OF EARTH RESOURCES  
SATELLITES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 86  
(manuscript received 4 Oct 85) pp 103-112

[Article by V.K. Saulskiy]

[Abstract] An increase in the efficiency of satellite use for study of the earth's natural resources requires choice of the orbital parameters and structure of satellites in a space system in such a way as to ensure minimum frequency of global scanning. An approach is proposed which makes it possible to solve problems arising in the analysis and choice of the makeup, relative positioning and orbital parameters of satellites intended for periodic scanning on both the illuminated and dark sides of the planet. Computations are given for determining the duration of total scanning of a particular zone for a space system with fixed parameters, as well as for determining the parameters of a system for achieving a minimum frequency of scanning of a global zone when using a specific number of satellites. The approach is based on some image of an arbitrarily selected parallel and the points of intersection of this parallel by satellite transits. The most important properties of the observation network are defined. The procedures for constructing computer-processable multisatellite diagrams are given. An algorithm is written for solution of the analytical problem. The required frequencies of scanning by environmental satellites were determined in the example of three large space systems with the following parameters: 1) number of satellites 100, orbital altitude 871.95 km, scanning zone 69.4 km; 2) number of satellites 20, altitude 713.44 km, scanning zone 24.8 km; 3) number of satellites 5, altitude 707.52 km, scanning zone 689 km. The scanning periods for the three variants were 0.284, 4.81 and 0.412 days. Figures 5; references: 1 Russian.

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CSO: 1866/25

UDC 528.711.18(203):[553.98/.2:550.462]

POSSIBILITY OF USING SATELLITE MEASUREMENTS OF METHANE IN THE ATMOSPHERE TO  
STUDY GLOBAL DISTRIBUTION OF ITS SOURCES

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 42, No 6,  
Jun 86 (manuscript received 20 Aug 84) pp 47-50

[Article by F.M. Gadzhi-Zade, I.S. Guliyev and A.A. Feyzullayev, Scientific-  
Production Association of Space Research, Azerbaijan Academy of Sciences]

[Abstract] Some results are presented from interpretation of spectra measured on the "Meteor-28" weather satellite by measuring the departing radiation of the Earth. Processing of spectral measurements established that the concentration of  $\text{CH}_4$  varies widely throughout the entire thickness of the atmosphere, with high concentrations over Northwest Europe, a portion of the Atlantic Ocean, the Far East and the Red Sea and minimum concentrations in some areas of North Africa, Eastern Siberia and Southern Asia. A map illustrates high methane content areas over Europe and Asia. Aircraft and surface measurements have demonstrated the possibility of formation of elevated and stable concentrations of methane in the atmosphere over oil and gas accumulations. This confirms the conclusions drawn from satellite measurements of the possible association between nonuniform spatial distribution and nonuniform regional distribution of oil and gas deposits. A three-stage gas search method is suggested, utilizing satellite measurements, aircraft and surface measurements, followed by surface gas-geochemical surveys of the most promising areas. Figures 2; references 5: Russian.

6508/8309  
CSO: 1866/57

UDC 550.837

METHOD OF REMOTE DETERMINATION OF HEAT FLUX AT THE OCEAN-ATMOSPHERE INTERFACE

Moscow IZVESTIYA VYSSHIKH UGHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOSYEMKA in Russian No 5, Sep-Oct 86 (manuscript received 4 Nov 85) pp 117-120

[Article by Yu.A. Ilin, Docent, Candidate of Technical Sciences, A.A. Kuznetsov, Docent, Candidate of Physical-Mathematical Sciences, and V.A. Malinnikov, Docent, Candidate of Physical-Mathematical Sciences, Moscow Order of Lenin Institute of Geodetic, Aerial Photo Surveying and Cartographic Engineering]

[Abstract] A Soviet national program (the "Razrezy" program) is studying the interactions of the atmosphere and the ocean to develop long-term weather forecasts and climate theory. As yet, however, there are no accepted methods for remote determination of heat flux at the ocean-atmosphere interface. The possibility of creating such a method is discussed in this article. The contact heat flux and heat flux going to evaporation can be measured only by methods using complex, nonstandard apparatus, and are therefore usually calculated, with only the effective radiation heat flux being measured directly by satellites. Equations used for these calculations contain imperical coefficients and have errors of up to 40 percent. Improved equations are presented for estimation of the heat flux, using coefficients which can be measured from satellites. The new equations have errors of not over 10 percent, indicating that the method suggested is promising for calculation of Q based on remote sensing data. References 6: 4 Russian, 2 Western.

6508/8309  
CSO: 1866/59

SPACE POLICY, ADMINISTRATION

REFERENCE TO SOVIET SPACE SHUTTLE PROGRAM, LANDING STRIPS AT BAYKONUR

Moscow TRUD in Russian 7 Apr 87 p 3

[Article by V. Golobachev, special correspondent at Flight Control Center, Kaliningrad  
"Two Hundred Meters from the 'Mir'"]

[Excerpt] Today no one is surprised by launches of manned space ships or the placing into orbit of long-duration stations. It is, as they say, the usual work. But the work itself does not become any easier from this sense of routineness. As before, it demands courage and the concentration of all one's powers. Space is developing rapidly. New projects are in preparation, including new modules for the "Mir."

Soviet scientists and designers are working on the creation of a multiple-use space transportation system. Such a system of ours will operate in parallel with the usual booster rockets whose use for delivering cargo into space is in many cases more advantageous economically.

In the creation of the multiple-use space transportation system there have been taken into consideration the shortcomings which became apparent in the operation of American ships of the type "Atlantis," "Columbia," and "Challenger." And what is most important -- as distinct from the American "Shuttle" our multiple-use transportation system will be used only for peaceful tasks and will contribute to the study of space in the name of mankind.

Several special landing strips have already been constructed for Soviet multiple-use ships at the Baykonur cosmodrome. They could also receive the American "Shuttle" in case of necessity.

CSO: 1866/86-P

## SPACE POLICY, ADMINISTRATION

### PLANS PROCEED FOR SOVIET LAUNCH OF INDIAN IRS-1 SATELLITE

Moscow KOMSOMOLSKAYA PRAVDA in Russian 2 Apr 87 p 3

[Article by Ye. Kavelina, correspondent (New Delhi)]

[Excerpt] A group of eminent Soviet researchers, organizers and developers of various branches of Soviet science visited India recently. The delegation was headed by G.I. Marchuk, president of the USSR Academy of Sciences.

"The leaders of our countries have presented scientists of the USSR and India with impressive tasks; we must find practical and maximally effective ways of advancing our scientific-technical cooperation," said G.I. Marchuk at a meeting with journalists.

The journalists asked about specific undertakings. Indian scientists are now completing work on a new satellite, the IRS-1, in Bangalore, the country's science capital. Plans call for launching this satellite from the territory of the USSR this year. Questions addressed to A.I. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research, were therefore concerned primarily with the progress of preparations for placing the new satellite into orbit.

"The satellite is intended for the study of natural resources," explained A.I. Dunayev. "It weighs 900 kilograms. It was developed entirely by Indian specialists. The Soviet side has the task of placing it into a polar orbit synchronous with the sun and of controlling it. The launch is scheduled for October."

Space is not the only area of Soviet-Indian scientific-technical cooperation. Next in line are joint developments in such fields as biotechnology, immunology, powder metallurgy, and production of industrial diamonds and lasers. Moreover, there are plans to establish cooperation in the fields of radiophysics and astrophysics, and to solve problems of ecology and oceanography. A memorandum on cooperation in study of the Indian Ocean was thus signed as a result of the Soviet scientists' visit to India, for example.

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CSO: 1866/97



A.B. SEVERNYY (OBITUARY)

Moscow IZVESTIYA in Russian 9 Apr 87 p 6

[Excerpt] Soviet science has suffered a grave loss. Academician Andrey Borisovich Severnny, an eminent Soviet scientist in the field of astrophysics and science organizer, died on 4 April 1987, at the age of 73. He was a member of the Communist Party of the Soviet Union, a member of the bureau of the USSR Academy of Sciences' Department of General Physics and Astronomy, a hero of Socialist Labor and a laureate of USSR State prizes.

A.B. Severnny's name is associated with outstanding achievements in the fields of solar and stellar physics, astronomical-instrument building, and the shaping of extra-atmospheric astronomy in the USSR.

After graduating from Moscow State University in 1935, his entire working career was connected with the USSR Academy of Sciences. He was a senior science associate of the academy's Crimean Astrophysical Observation from 1946, and director of the observatory from 1952.

A.B. Severnny studied nonstationary processes on the sun, and he discovered and studied a connection between the occurrence of solar flare-ups and features of magnetic fields. Seasonal and daily fluctuations of the sun's overall magnetic field and global pulsations of the sun were discovered under his direction. He discovered weak magnetic fields of stars, as well as circular polarization of light in many stellar objects.

A.B. Severnny contributed in many ways to the advancement in our country of scientific research with the aid of space technology. A number of space experiments were carried out under his personal direction, including development of the orbiting solar telescope "OST" and an ultraviolet space telescope which operated successfully in space and yielded a number of important scientific results.

A.B. Severnny was a member of the editorial boards of a number of journals, and he was chairman of the USSR Academy of Sciences' scientific council on the problem "Extra-Atmospheric Astronomy."



Academician A.B. Severnyy's services were highly appreciated by the Communist Party and the Soviet state. The high title of Hero of Socialist Labor and state prizes were conferred upon him, and he was awarded many orders and medals.

(The obituary is submitted by the presidium of the USSR Academy of Sciences and the academy's Department of General Physics and Astronomy, Crimean Astrophysical Observatory, joint scientific council on the large-scale problem "Astronomy," scientific council on the problem "Extra-Atmospheric Astronomy," and Astronomical Council.)

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## LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
31 Mar 87	Kvant	320 km	177 km	89.2 min	51.6°
		(Astrophysics module; carries "Roentgen" observatory and "Glazar" UV telescope; scheduled to dock with Mir station on 5 April; docking took place on 9 April)			
8 Apr 87	Cosmos-1834	443 km	413 km	92.8 min	65°
9 Apr 87	Cosmos-1835	367 km	180 km	89.7 min	65°
16 Apr 87	Cosmos-1836	313 km	188 km	89.2 min	65°
21 Apr 87	Progress-29	257 km	194 km	88.7 min	51.6°
		(To deliver supplies to the Mir station)			
22 Apr 87	Cosmos-1837	255 km	198 km	88.7 min	82°
24 Apr 87	Cosmos-1838, -1839, 1840	17,550 km	213 km	5 hrs 12 min	64.7°
		(3 satellites orbited by single launcher)			
24 Apr 87	Cosmos-1841	403 km	225 km	90.5 min	62.8°
		(Carries apparatus for continuing research on space materials science begun on the Cosmos-1645 and Cosmos-1744 satellites; will conduct experiments on semiconductor materials and biological preparations; flight scheduled for 14 days; test samples will be returned to earth)			

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
27 Apr 87	Cosmos-1842	678 km	648 km	97.8 min	92.5°
5 May 87	Cosmos-1843	312 km	214 km	89.5 min	70.4°
11 May 87	Gorizont	35,174 km	--	23 hrs 21 min	0.52°
		(Communications satellite for further development of communication systems and TV broadcasting; near-stationary orbit)			
13 May 87	Cosmos-1844	879 km	861 km	102 min	71°
13 May 87	Cosmos-1845	400 km	217 km	90.4 min	70°

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18 Aug, 1987

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